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THE BRITISH SULPHUR CORPORATION LTD.,
4, GRAFTON STREET,
LONDON, W.1.

Telephones : HYDE PARK 8989
GROSVENOR 5606

Telegrams : SULFEX, PICCY, LONDON

Cables : SULFEX, LONDON

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Review

THE Sulphur Industry of Canada expanded during 1955 at a faster rate than industrial activity as a whole mainly on account of the impact of sulphur on the pulp, chemo-metallurgy, oil and gas industries which were the fastest growing sections of the Canadian economy. Production of sulphur in various forms of 657,355 short tons was over 100,000 tons greater than the 1954 record output, the bulk of the increase consisting of by-product pyrites shipments, partly to export, partly to meet the needs of a new sulphur/sulphur dioxide plant of Noranda Mines Limited at Port Robinson. Its successful operation, which is soon to be copied on a larger scale by Algom Uranium Mines, paved the way for the better utilisation of the vast pyrites resources of Eastern Canada. It is estimated that total sulphur consumption amounted to 790,000 short tons, one sixth more than in 1954, of which nearly one-half was imported U.S. brimstone. The advancement in 1955 of the Trans-Canada and Peace River gas pipe-line projects and the related gas cleaning and sulphur recovery projects have laid the foundation for the large scale exploitation of the seemingly unlimited sulphur resources in sour natural gas in Alberta. It is confidently anticipated that recovered sulphur output which in 1955 amounted to 29,094 short tons, should by 1958 approach half million tons annually and soon after, rise to one million tons. Supplies of this magnitude much exceed Western Canada's needs even allowing for the expansion of the local sulphur markets by the growth of chemical, metallurgical and processing industries, under the stimulus of the abundant natural resources of the Western provinces, especially of Alberta. This surplus is likely to find its most profitable outlet in overseas markets, as, like so many Canadian industries, recovered sulphur is affected by the distance between source and main domestic market which, in terms of rail transport costs, restricts the economic radius of supply. It is therefore, probable that consumers in Eastern Canada, who currently account for three-quarters of total Canadian sulphur usage, will continue to depend primarily on elemental sulphur imports, although by-product pyrites, sulphuric acid and liquid SO_2 are expected to play an increasing part in meeting the growing Canadian sulphur needs.

Fisons Limited, one of the largest fertilizer manufacturers in the United Kingdom and specialising in the manufacture of superphosphates, are responsible for about one-half of the phosphatic and potassic fertilizers and about 30% of the nitrogenous fertilizers sold in the U.K. The company's activities are reviewed against the background of British agriculture which, notwithstanding Fisons many other interests at home and abroad, is still the company's most important market.

In the **United States** of America production of Frasch and recovered sulphur during the second quarter amounted to 1,725,408 tons, the second highest quarterly total on record. Apparent sales, although 2% lower than the record tonnage sold during the second quarter of last year, reflect a decrease of almost 14,000 tons in exports to 406,000 tons, while the domestic market was narrowed by 45,000 tons imported sulphur from Mexico. Although 3-4% lower than in the first quarter and reflecting the three point decline of the index of industrial production to 141, domestic sulphur consumption was 1-2% higher than in the second quarter of last year. Sulphuric acid output increased 1¼% to 4.02 million short tons and sulphur usage for non-acid purposes, notably pulp and rayon, also rose. The further addition of 125,000 tons to Frasch and recovered sulphur stocks raises them to 3.3 million tons, the highest level for over seven years. During the summer months, stocks are reported to have risen further as the high level of output was not adjusted promptly to season-

ally lower usage, which was accentuated by the effect of the steel strike. Unless domestic consumption in the last quarter of the year proves to be exceptionally high, U.S. producers, whose income from exports is now reduced, will not be able to achieve a gross revenue comparable with last year's.

Off-shore sulphur production has in two years advanced from theoretical probability to practical realisation as the result of the agreement concluded at the end of September between Freeport Sulphur Company and Humble Oil and Refining Company in respect of the latter's dome at Grand Isle-Block 18. To exploit the dome, which is situated in the open water of the Gulf of Mexico, 6 miles off the Louisiana shore, Freeport are to construct a Frasch sulphur plant on a high steel platform and move the sulphur output in liquid form to their main storage and loading installations at Port Sulphur. In view of the company's extensive experience of operating in swamp and coastal regions they are confident of success in this enterprising undertaking. Although this off-shore dome makes an important addition to exploitable reserves, its value depends on the company's ability to produce sulphur at a cost comparable with those prevailing at established domes.

At the **Bonnie Chemical Plant** in Florida the International Minerals and Chemical Corporation earlier this year initiated a $4 million expansion programme. One of its features has been the modification of the existing sulphuric acid unit, the largest in the world, which has increased its actual capacity by nearly 30%. Sulphuric acid requirements for the planned phosphoric acid output are to be met by duplicating the present installations; when completed in June 1957, phosphoric acid output—the processing of which is integrated with uranium oxide extraction at a daily rate of 200 lbs. U_3O_8—will enable the company to produce nearly ½ million tons triple superphosphate, four times as much as at present.

In **Italy**, the fiscal year of Ente Zolfi Italiani, which terminated on 31st July, proved to be an encouraging period without however leaving any room for complacency. Having secured Government financial support in the form of production and export subsidies, E.Z.I. was once more able to sell Italian sulphur competitively in selected foreign markets. Deliveries to the home market of 117,000 tons and to export of 92,000 tons together exceed production of 178,000, with the result that it became possible to reduce the stockpile to 307,000 tons. The further advances along the road of technical and commercial progress, that may be achieved by E.Z.I. this year, are likely to indicate the prospect of the Italian sulphur industry eventually achieving independent economic stability.

Frasch sulphur shipments from **Mexico** are mounting rapidly and in the first nine months of this year they totalled about 328,000 tons nearly three times as much as in the same period of last year. Recently, following the eclipse of Mexican Gulf Sulphur Company and pending the start of major shipments by the Gulf Sulphur Corporation, deliveries have been almost exclusively confined to Pan American Sulphur Company who anticipate producing and shipping about ½ million tons this year. Now that their filtering plant is operating, quality, expressed by colour and carbon content, has been improved and with the expansion of the water capacity the Company claims to be able to produce at an annual rate of 1 million tons. Gulf Sulphur Corporation, producing at 400 tons per day, is building stocks and executing some shipments for Mexican Gulf Sulphur Company, while developing her own markets and custom. The start of steaming operations at Texas Gulf Sulphur Company's Santa Anita dome is imminent, while Texas International Sulphur Company is planning, with new financial support, to build a 1,000 tons per day Frasch plant.

Consumpton of sulphur in the **United Kingdom** during the 2nd quarter 1956 amounted to 230,000 tons, 5% less than in the preceding quarter but 7½% more than in the same period last year, although no significant change in the index of industrial production had taken place. Under the stimulus of constantly expanding requirements by the titanium dioxide and detergent industries and due to greater use in fertilizer manufacture, sulphuric acid consumption of 558,900 tons, was 7% more than last year. Greater consumption of brimstone for non-acid use as well as for acid making, and anhydrite consumption twice as large as this time last year, contrasted with lower pyrites, spent oxide and zinc concentrate

consumption. Pending the impact of the new brimstone acid plants under construction and due to start next year, the new pattern of sulphur consumption appears to be almost established.

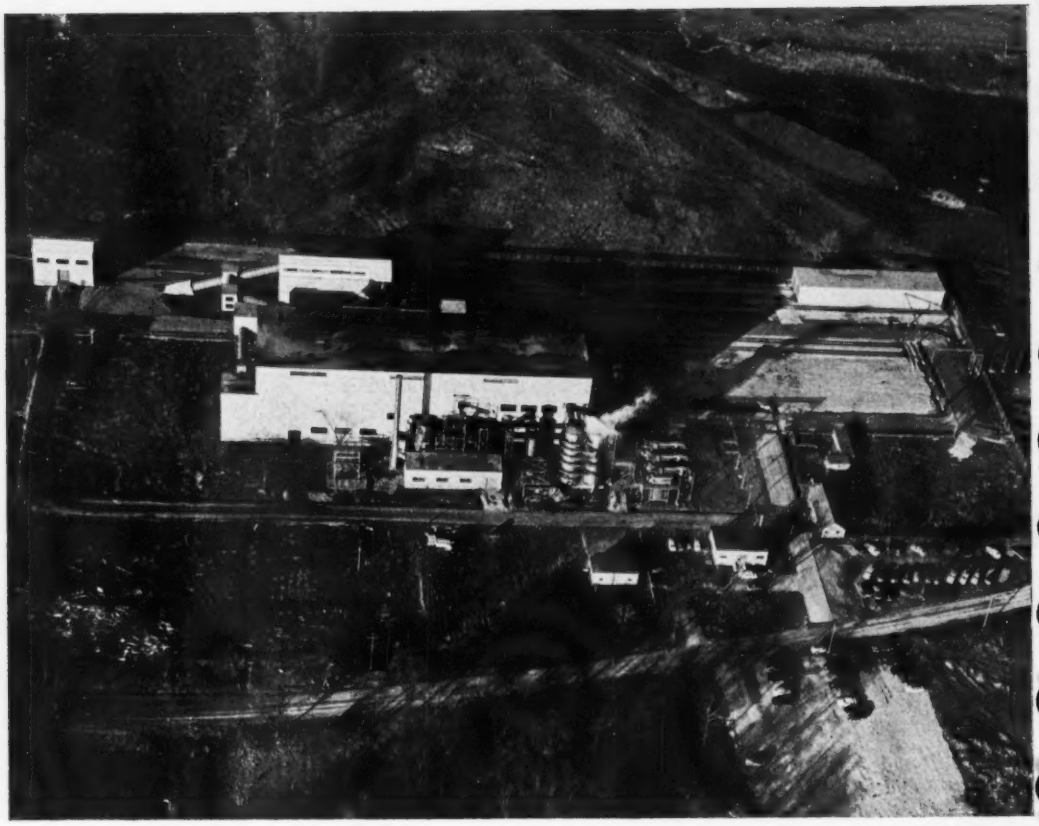
A revolutionary method of nickel refining wholly by chemical means and resulting in use and recovery of sulphur, is in operation at the Fort Saskatchewan plant of **Sherritt Gordon Mines Limited**, near Edmonton. The treatment of nickel-copper concentrate from the company's Lynn Lake mine in Manitoba consists of a series of processes—ammonia leaching and chemical oxidation and reduction steps—in the course of which 70% sulphur content of the ore is recovered in the form of ammonium sulphate. At the current rate of operation over 10,000 tons sulphur is annually recovered in this form.

Sulphur recovery from total gasification of coal is practised at the new plant of Steinkohlengas AG. of Dorsten, Westphalia. From crude gas resulting from the combustion of 1,000 tons per day weakly caking high volatile gas coal, hydrogen sulphide is extracted by the Alkazid process, which allows 90-95% sulphur extraction, the balance being removed by dry (ferric oxide) purification. Hydrogen sulphide liberated from the alkazid lye when this is regenerated, is converted to 60% Bé sulphuric acid in a 30 tons per day wet contact acid plant. This means of coal gasification and gas treatment allows the economic recovery of practically the entire sulphur content of the coal, compared with little more than 30% in town gas or coke oven gas manufacture.

World prices of sulphur have remained stable during the past three months. Following the elimination of the anomalous differential between export and domestic prices all U.S. producers are now basing their prices on $28 per ton f.o.b. for bright sulphur. The quality discount for off-colour sulphur is now $1 in both home and foreign markets. In Mexico, Pan American Sulphur Company's new filtered output of good colour and quality is securing $26-26.50 per ton f.o.b., while off-colour sulphur is being offered at under $25. Italian and Chilean prices tend to be based on the Mexican quotations.

Although about 5% higher than at the beginning of July, sulphur freights have not been significantly affected by the Suez crisis. A combination of adverse conditions could cause freights to rise beyond the peak levels reached in the Spring, but it is expected that during the coming 8-10 weeks sulphur freights may be maintained at or near present levels.

World supplies of sulphur and stocks are mounting. For the present actual and potential sulphur supplies have outrun the rate of expansion of demand.



Noranda Mines Limited new sulphur/SO_2 plant. From l. to r. Unloading shed, main process building, gas cooler, gas scubbers, mist cottrells and thaw shed.

parison with other sulphurous raw materials now it is also influenced by the enhanced value and versatility imparted by the resultant pure sulphur and iron sinter. The Port Robinson plant is designed to produce, daily, 62 tons elemental sulphur and 250 tons iron sinter which are marketed directly, while 240 tons SO_2 in the form of 7% gas is carried by pipeline to the adjacent plant of North American Cyanamid Company for conversion to sulphuric acid for use in fertilizer manufacture. Notwithstanding many years of experimental work and 5 years testing in a 50 tons per day pilot plant, the full scale plant—based on a daily throughput of 370 tons pyrites—ran into teething troubles which are reported to have been resolved, in co-operation with the plant makers—Chemical Construction Company. No details of the exact economics of the Noranda process have yet been released, but the decision by Algom Uranium Mines Limited—the Canadian subsidiary of Rio Tinto Ltd.—to instal a similar and one-third larger plant, speaks for itself.

Sulphuric Acid

The start of operations in 1955 of two new plants augmented the number of acid plants in Canada to sixteen. The new 100 tons per day acid plant of Inland Chemicals Limited at Fort Saskatchewan is based on supplies of sulphur recovered from natural sour gas at the Jumping Pound plant of Shell Oil Co. A large part of its acid output is supplied to the adjacent nickel refining plant of Sherrit Gordon Ltd. to supplement the by-product manufacture of ammonium sulphate. Gunnar Gold Mines Ltd. at Uranium City, Saskatchewan also based their new acid plant on sulphur recovered by

Shell Oil Co. Like the three plants of Eldorado Mining and Refining Company—two at Great Bear Lake and one at Uranium City—this new privately owned plant provides acid required for uranium ore leaching.

According to preliminary official estimates acid output in Canada in 1955 was 920,000 tons (100% H_2SO_4) or about the same as during the preceding year. On the basis of the apparent consumption of sulphur and sulphurous raw materials the actual acid output is estimated to have been at least 10% greater. An important plant project started in 1955 is the $25 million acid/fertilizer plant of Northwest Nitro-Chemicals Limited at Medicine Hat, Alberta (see Quarterly Bulletin No. 11, p. 27).

Recovered Sulphur

When the Shell Oil Company's second expansion project was completed in January 1955, raising plant capacity from 30 to 80 tons per day, Canada's recovered sulphur production capacity totalled about 110 tons per day, the balance arising at Royalite Oil Company's Turner Valley plant. These developments were virtually integrated with the corresponding growth of consumption facilities in the pulp and sulphuric acid industries of Alberta and British Columbia.

The further expansion of plant capacity which was initiated in 1955 springs from the necessity of cleaning the gas supplies designated for the various long distance transmission projects. These include :

(i) The 300 tons per day sulphur plant at Port Pouce in North Eastern British Columbia which Jefferson Lake Sulphur Company is building in conjunction with the Pacific Petroleum Company's plant. This is designed to clean gas from the Peace River fields prior to its transmission through British Columbia to the North West U.S.A. It is due for completion in the autumn of 1957. (See Quarterly Bulletin No. 13, p. 35).

(ii) The 225 tons per day sulphur plant of British American Oil Company (formerly Canadian Gulf Oil Company) at Lethbridge, Pincher Creek which will convert H_2S extracted from gas to be supplied to Trans-Canada Pipe Lines Limited. This is due to be completed this autumn. (See Quarterly Bulletin No. 11, p. 27).

(iii) The 20 tons per day sulphur plant of Imperial Oil Ltd., to convert H_2S extracted from a daily supply of 9 million cu. ft. of natural gas from Redwater field to Calgary. It is due to come on stream in November 1956.

By the end of 1955 Royalite Oil Co. working in conjunction with Can-Amera Oil Co., had advanced their developments on the utilisation of Athabasca Tar Sands sufficiently to promise economic recovery of oil products and sulphur in the foreseeable future. (See Quarterly Bulletin No. 12, p. 37).

Conclusion

The development of Canada's sulphur industry in 1955 was not only impressive on account of the expansion in both output and usage but also in respect of improved versatility of outlets for the country's enormous pyrites potential as a result of the successful working of the Noranda process. In that year the foundations were also laid for the large scale recovered sulphur industry based on the sour natural gas of Alberta. This development raises in sulphur a problem which is already familiar to other branches of Canadian industry in that, owing to great distances and the consequent influence of rail-freights on the economic radius of supply, established users are unable to take advantage of newly found and abundant indigenous resources.

Already in 1955 the necessary cleaning of natural gas supplies resulted in the production of about 29,000 tons sulphur. The provision of the ever increasing requirements of long distance gas transmission, east from Alberta and south from British Columbia, will result in an output of ½ million tons sulphur within two years and probably 1 million tons annually soon after. The present output has been absorbed partly by established users in the pulp industry and partly by newcomers of the chemical and chemo-metallurgical industries. There is no doubt that the abundance of raw materials and energy supplies will attract more and more industries to the West but their sulphur requirements cannot possibly absorb supplies of that magnitude.

The industry can look for disposal facilities either to the established market in Eastern Canada and U.S.A.—Western U.S.A. is already almost self-sufficient on recovered

sulphur—or to exports through Vancouver. On relative distance and rail charges and without regard to the available carrying capacity of the trans-continental railway, it appears unlikely that the Western sulphur can supplant in the Eastern Provinces imported Frasch sulphur, or if an attempt were made at competing that the Eastern Canadian or U.S. markets would offer the attractions of overseas export markets.

Therefore it appears probable that sulphur consumers in Eastern Canada will, in the main, continue to depend on imports although an increasing proportion of new requirements are likely to be met by by-product—pyrites, acid and liquid SO_2—supplies of the expanding base metal industries. The West on the other hand developing independently may be expected to become a major source of supplies to the world sulphur market.

Fisons Limited

Introduction

FISONS have been producing chemical fertilizers, in particular superphosphates, since the middle of the nineteenth century, when the three parent companies, Joseph Fison & Co. Ltd., Packards & James Fison (Thetford) Ltd., and Prentice Bros. Ltd., were founded. In 1929 the three companies amalgamated and in the following ten years extended their activities from East Anglia into all parts of the country by the acquisition of several smaller fertilizer manufacturing companies. In 1937 the company participated in the formation of Nitrogen Fertilizers Ltd., at Flixborough to manufacture sulphate of ammonia.

The first step in extending the company's interests outside fertilizers was taken before the war, when in 1937 the company acquired the Anglo-Continental Guano Works Ltd. and at the same time its subsidiary Genatosan Ltd., manufacturers of drugs, pharmaceuticals and fine chemicals. After the war it was decided to extend the company's interest in this field by acquiring Whiffens and Sons Ltd., and Bengers Ltd. In 1954 the agricultural chemical field was entered with the purchase of Pest Control Ltd. A 50% interest in Murgatroyd's Salt and Chemical Co. Ltd. extended the Group's interests to heavy chemicals in the same year. In Northern Ireland, Fisons Milk Products Ltd., process over 8 million gallons of milk a year into a range of milk products.

Associated companies overseas in which Fisons have interests are situated in the U.S.A., Canada, South Africa and Rhodesia. These companies are primarily concerned with fertilizer manufacture.

The capital employed in the Fisons Group is over £20 million made up of share capital £10,064,000, capital reserve £3,375,000, loan capital £3,373,000 and revenue reserves £3,652,000. The Chairman in his review for the year ending 30th June 1955 gave the turnover of the Group as £32 million, while trading profit and investment income before taxation was £2,645,000 of which taxation absorbed £1,220,000 and dividends (net) £579,000.

Despite these recent developments by the company in the fields of heavy chemicals and fine chemicals, the primary interest is still in agricultural and horticultural fertilizers. It operates ten producing factories for superphosphate throughout the United Kingdom, in addition to a number of mixing units. Fisons fertilizers play an important part in U.K. agriculture, so some brief comment on the company's main market is relevant.

U.K. Agriculture

It is by now fairly clear from the recurrent weakness in the U.K.'s trade balance that agriculture has a very essential role to play in restraining increases in the volume of imports. The neglect of the past and the peculiarities of the industry require that agriculture receives Government support in order that it can play the role required of it. Government policy is now directed at inducing agriculture to concentrate on lines of production which will most effectively relieve the balance of payments—the substitution of home grown feed and in particular, the better use of grassland and continued expansion in the output of beef, mutton and lamb. As part of its policy of agricultural support the Government has come to attach greater importance to production grants. Within this scheme the farmer is

offered subsidies on his fertilizer purchases as an inducement to the more effective use of his land. Already agriculture has achieved very significant expansions in output by extensive mechanisation and the adoption of new techniques. The net output of U.K. agriculture during the current season is estimated to

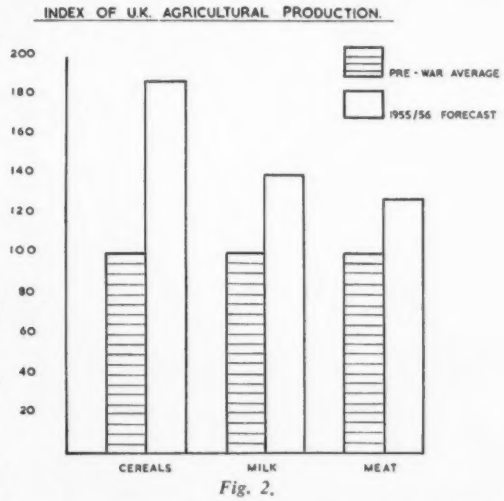


Fig. 2.

be 54% above pre-war. Comparative details of output of some agricultural products are as follows:—

	Cereals (000 tons)	*Milk (mill. gls).*	*Meat (000 tons)*
Pre-war Average	4,442	1,563	1,208
1955/56 Forecast	8,771	2,184	1,541

Use of Fertilizers

The expansion in agricultural output is due in part to the sizeable increase in use of fertilizers since before the war. Consumption of P_2O_5 has doubled, while that of N has increased fourfold and K_2O threefold.

Consumption of straight phosphatic fertilizers has decreased in recent years although in 1955/56 the use of basic slag has again increased to reinforce the steady expansion which has been taking place in consumption of P_2O_5 in compounds. The proportion of N used in compounds has increased at a slightly lower rate compared with P_2O_5.

U.K. Consumption of Fertilisers

	P_2O_5 *000 tons*	*N 000 tons*	K_2O *000 tons*
1952/1953 ...	400.0	230.1	231.0
1953/1954 ...	379.7	241.5	251.0
1954/1955 ...	340.8	248.2	252.5

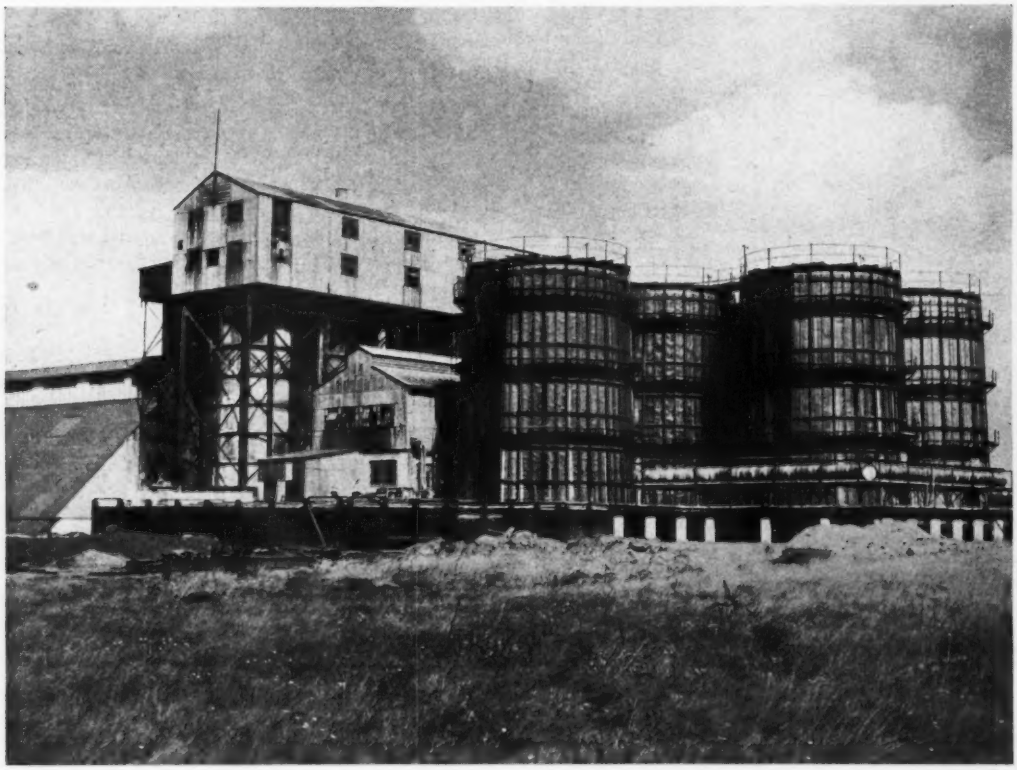
Despite the increased use of fertilizers since before the war, there is still considerable scope for further expansion. Rates of fertilizer application vary widely between different crops. In particular, use on grassland tends to be very low and perhaps as much as 60% of the acreage receives no fertilizer dressing. As Government policy is seeking to promote the more effective use of grassland, which accounts for two-thirds of total U.K. acreage, the potential additional fertilizer requirement is very substantial.

It seems unlikely that consumption of the three plant nutrients will expand at the same rate. Expansions in use of N and K_2O are likely to continue to outstrip increases in consumption of P_2O_5. The tendency for the use of P_2O_5 in compounds to increase will compensate in the coming years, for the decline which is expected to continue in the consumption of straight superphosphate.

Sulphur in Agriculture

The importance of sulphur in plant nutrition is not fully recognized although it ranks in importance with phosphorus as a constituent of all proteins. It has been estimated that the plant food content ($N: P_2O_5: K_2O: SO_3$) of all the food crops harvested in the U.S.A. is in the ratio of 1.0:0.4:0.6:0.3. Although a substantial proportion of the sulphur requirements of crops reach the soil through precipitation and by direct sulphur dioxide assimilation from the atmosphere, important contributions are made by fertilizers, in particular superphosphate and ammonium sulphate. Small quantities of sulphur are applied direct in the form of pesticides and fungicides and in some instances are applied as a soil conditioner. It is not as yet known if the change to the use of more concentrated types of fertilizers, with reduced sulphur content, will make for any actual sulphur deficiency in British agriculture. This problem is receiving the attention of Fison's research establishment. The possibility of a substitute for the use of sulphuric acid in fertilizer manufacture received particular attention during the sulphur crisis of 1950. Attention was especially focussed on the production of nitro-phosphates, but so far this has not led to their manufacture in the U.K. It is thought unlikely, given an economic supply of sulphur and sulphuric acid, that this form of production will assume any importance.

The fertilizer industry is by far the largest single user of sulphur in all its forms. A large proportion is consumed in the form of sulphuric acid in the manufacture of superphosphates and of some ammonium sulphate. Although phosphate rock itself supplies some plant nutrient to the soil, P_2O_5 is made more easily available to plants if the rock is treated with sulphuric acid to produce superphosphates. In the U.K. the use of sulphuric acid in the manufacture of ammonium sulphate is limited to about one-third of the total output, i.e. by-product ammonia and the output of synthetic ammonia at Flixborough. The balance results from the direct manufacture from synthetic ammonia, CO_2 and anhydrite which in this case represents the sulphur constituent.



Mills-Packard Towers at Cliff Quay, Ipswich, Acid/Fertilizer Plant.

U.K. Consumption of Sulphur

Year	*Total 000 tons sulphur*	*Used in fertiliser manufacture 000 tons sulphur*	*% of acid output*
1951	836	391	37.3
1952	805	426	41.8
1953	958	476	40.4
1954	1,042	463	36.4
1955	1,077	477	36.3

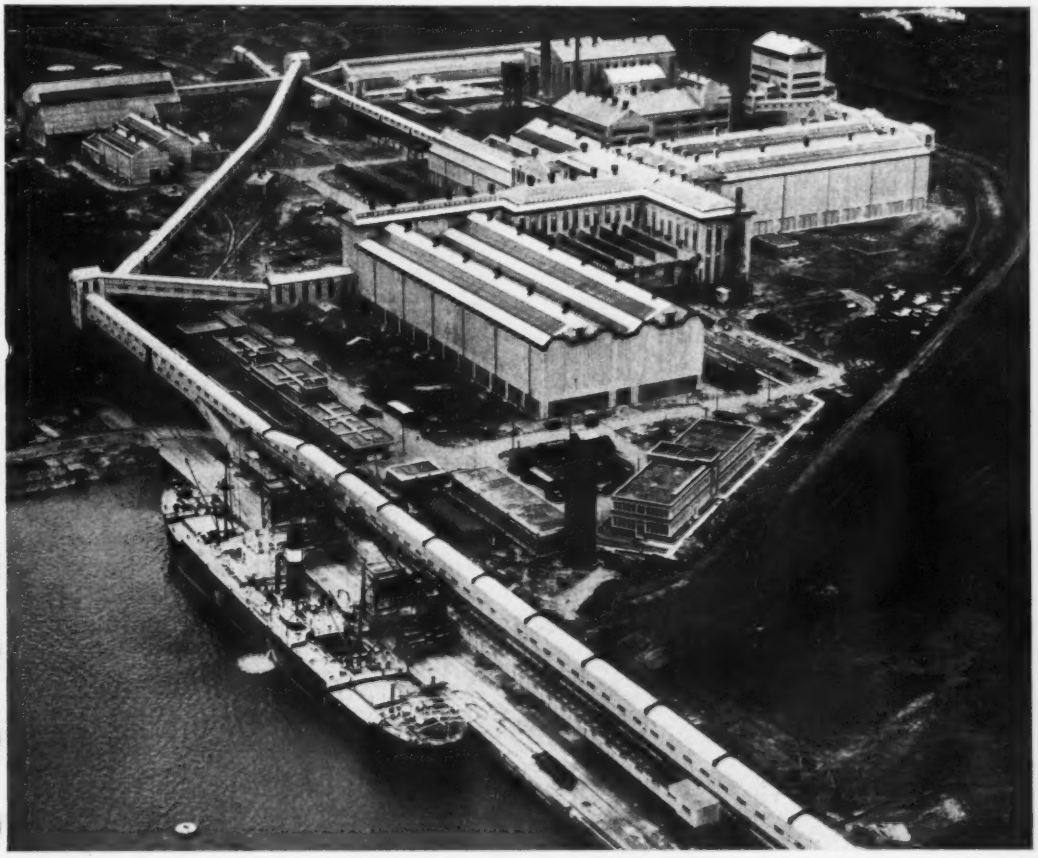
Fisons Fertilizers

Fisons specialise in the production of superphosphates, the larger proportion being used in compound fertilizers. The company is responsible for about one half of the phosphatic and potassic fertilizers consumed in the U.K., and sells just under 30% of the total amount of nitrogen used by farmers.

In recent years Fisons have stimulated market demand for more concentrated fertilizers and for compounds. Triple superphosphate, 43%-49% P_2O_5, has expanded at the expense of single superphosphate, of only 16%-21% P_2O_5, but the greatest development in post-war years has been in the provision of concentrated compound fertilizers. Sales of concentrated compounds based on triple superphosphate, the "30" range, have

developed so rapidly that they have now practically replaced the ordinary compound range.

Fisons were pioneers in the manufacture of granular fertilizers. In the mid 1930's they began to develop the market for granular superphosphates and granular compounds.



The Immingham Fertilizer Plant.

The provision of granular concentrated compounds was made possible when granular triple superphosphate was first produced at Immingham in 1951. The latest development has been the provision of a concentrated compound combined with an insecticide, the "31+Aldrin."

Fisons Sulphuric Acid

Fisons are one of the three largest users of sulphuric acid in the U.K. Several of the Company's fertilizer plants include installations for acid manufacture which meet part of the requirements for the manufacture of superphosphate and of ammonium sulphate.

In addition, the company purchases considerable quantities of sulphuric acid. Fisons operate eight sulphuric acid plants. The smaller and generally older plants are based on the use of pyrites or spent oxide or a combination of these raw materials, and their conversion facilities consist mostly of lead chambers or towers. At Flixborough, a major reconstruction programme is on the point of completion which will replace old pyrites furnaces with modern production facilities for forty thousand tons per annum contact acid based on the use of sulphur filter cake. About 95,000 tons acid are produced from elemental sulphur, the bulk at the Immingham plant, which, completed in 1951, still boasts the largest single converter unit in

this country. Its output is used in the production of phosphoric acid required for the

Fig. 3

manufacture of triple superphosphate and in view of the rising demand for this fertiliser a second almost identical sulphuric acid plant is now under construction.*

In 1951 Fisons participated with ten other leading acid manufacturers in the formation of the United Sulphuric Acid Corporation Limited. A large anhydrite acid plant was built at Widnes to reduce the dependence of acid users on imported raw materials. The plant, which has an annual capacity of 148,000 tons acid, was completed in the spring of 1955. Fisons hold a 23½% interest in this venture.

Summary

As indicated in the introduction, Fisons interests now extend through a very wide range of industry. However, this review looks at the Company against the background of its traditional and still most important market —British Agriculture. During and since the war U.K. agriculture has been called upon for sustained efforts to increase its contribution to British food supplies. Throughout this period the fertilizer industry has been able to meet the need for one of the essential means of assuring this increase in agricultural output. It is evident that with the increasing need to reduce unit production cost, fertilizers will have an even more important place in the agricultural future, and Fisons intend to continue providing the farmer with the types of fertilizers most suited to his requirements. To this end one of the crucial factors remains the adequate and economic supply of the raw materials amongst which sulphur, in some form, holds a prominent place.

We are indebted to Messrs. Fisons Limited for the information and illustrations which they kindly placed at our disposal.

Prices and Trends

Prices

WORLD prices of brimstone during the past three months have remained stable. Following the readjustment of their price policies, U.S. producers, who one by one between February and June had abandoned the fixed $3 export premium on shipments outside North America, are now basing sales at home and abroad uniformly on $28 per ton f.o.b. for bright sulphur. The discount for off-colour sulphur is now also uniform and both Texas Gulf Sulphur Co. and Freeport Sulphur Co. make an allowance of $1 per ton in this respect. It appears that by their realistic gestures of eliminating the price anomalies between domestic and export markets the U.S. producers have improved their relationship with many old overseas customers and although so far the price reduction does not appear to have resulted in U.S. exporters securing more overseas business, it may have restricted the amount of business which might otherwise have been lost to Mexican exports.

*See page 34.

Pan-American Sulphur Company which, following the virtual cessation of Mexican Gulf Sulphur Company's shipments and pending the expansion of those by Gulf Sulphur Corporation, has recently accounted almost exclusively for sulphur exports from Mexico is reported to be securing prices in the region of $26-26.50 per ton f.o.b. Coatzacoalcos on account of the good quality and colour of the new output of filtered sulphur. Mexican off-colour sulphur is reported to be on offer at under $25 per ton.

The Ente Zolfi Italiani continues to sell competitively in selected markets. Based on prices of L. 23,000-24,500 per metric ton (£13 7s.-£14 4s. per ton) for Buona Sicilia (min. 98%S) and Gialla Inferiore (min. 99%), special discounts varying according to destination are applied. These depend on relative landed cost of competing Mexican and/or U.S. sulphur which, governed by freight rates, has recently again moved slightly in Ente Zolfi Italiani's favour. In all sales Ente Zolfi Italiani appears to exercise very strict marketing control in order that recourse to subsidy—which remains limited to a top figure of L11,000 per metric ton (£6 8s. per ton)—may be minimised.

The following table shows a comparison of prices and of sulphur of different origin. F.o.b. prices and freight are based on recent quotations:

	f.o.b. Country of Origin	*Freight to† U.K.*	*per ton c.i.f. U.K.*
U.S.A.	$27—28	110s.	£15¼—15½
Mexico	$25—26.50	110s.	£14½—15
Italy/Sicily	L.23,000	60s.	£16⅜
Chile	U.S. $18—22	135s.	£13¼—14⅜
Ecuador	U.S. $42	135s.	£21⅜
Canada	$20 ex-works	135s.	£19½

†Based on bulk cargoes of 5,000 tons on the usual sulphur terms of chartering.

In Chile, it now appears to have been agreed between Snr. Jose Maza, President of the Sulphur Producers Association, and the appropriate Ministers and negotiating committees that all contracts between sulphur producers and importers of motor vehicles may be honoured up to the end of the year. It may be inferred that no new engagements of this nature may be started, but in view of anticipated difficulties in export markets, the Chilean sulphur producers are said to be pressing for the exclusive privilege of being permitted to continue receiving compensation from imported commodities. A further disturbing feature is the enactment of a law reserving 50% of all foreign trade to Chilean vessels. Although relatively insignificant if compared with the country's total volume of export trade which is estimated at £8 million per month, this added handicap, if enforced, could eliminate Chilean sulphur exports from world markets.

Pyrites

Prices of European pyrites for shipment during the 2nd half-year are ranging from £4 10s. to £5 per metric ton f.o.b., about 5% less than in the first half-year. Quotations up to 20% lower are reported from Czechoslovakia and Poland where Norwegian, Cypriot and low grade Spanish pyrites find a ready market, in competition with Jugoslavian, Roumanian, Bulgarian and, of course, local pyrites.

Canadian export pyrites to the United Kingdom and the Continent are reported to be available at about $4-$5 per long ton so that at ruling eastbound freight rates they are highly competitive with European pyrites.

Freights

Although during the period under review the Suez Canal crisis dominated shipping affairs, its effect on freight rates in general and sulphur and pyrites in particular has been relatively small. After receding in the latter part of June, freights have fluctuated and on balance increased about 5% The present sulphur freights from Gulf to Continent and the United Kingdom at 105s. to 110s. compare favourably with the firmer rates to Australia (140s. f.i.o.) and the Far East and India (170s.).

Pyrites freights from Huelva to the Continent are reported lower at about 42s., whereas from Eastern Mediterranean for a recently chartered 8,000 ton vessel carrying Cyprus pyrites 59s. was paid.

Whereas a combination of adverse factors, notably a surge in transatlantic coal trade and the extension to other markets of the growing demand for tonnage in the Far East on account

of grain and sugar shipments, might, as some shipping circles suggest, lead to a level exceeding the peak rates established earlier this year, it is expected that the present levels of sulphur and pyrites freights are likely to be maintained for the next 8-10 weeks.

Supplies

In the U.S.A. a substantial excess of Frasch sulphur output over domestic consumption and export shipments is resulting in regular additions to producers stocks which are now the highest for over seven years. In July the unprecedented monthly output of 621,000 tons occurred whilst domestic use was affected by the steel strike and as a result stocks rose by 162,000 tons. Towards the end of the third quarter the anticipated acceleration of industrial activity—accompanied by greater sulphur demand—has asserted itself, but rising recovered sulphur supplies and imports from Mexico are increasingly affecting many important domestic outlets for Frasch sulphur.

Output of Mexican sulphur, at present confined to Jaltipan and Las Salinas domes, is estimated to be about 1,700 tons per day. Successful filtering is enabling Pan American Sulphur Co. to offer large scale supplies of low carbon, good colour sulphur. Pending the development of outlets in world markets Gulf Sulphur Corporation's output remains limited to about 400 tons per day although the company is ready to raise daily production to 1,000 tons per day. The domestic market, which in any case is partly met by recovered sulphur supplies, is for the present making smaller demands than anticipated on Frasch sulphur. Stocks at mines and port are rising and by the end of the year are likely to total one-half million tons.

Exports and domestic deliveries of Italian sulphur account for little more than current output, which has been cut back to an annual rate of about 180,000 tons. In consequence, withdrawals from stockpile are slow and this remains in excess of 300,000 tons. On account of the increasing use of sulphur ore as a crude or part beneficiated raw material for sulphuric acid manufacture it appears that earlier labour troubles at the mines have abated.

The uncertainty of Chilean sulphur exports being permitted to continue seeking cost compensation from commodity imports is restricting production and at present no free supplies appear to be available.

Scandinavian and German recovered sulphur supplies were fully taken up domestically and increased imports have been required to meet demand.

In Japan there has been no change in the stringent supply situation. Imports of U.S. sulphur are bridging the gap which, it is reported, may be greater than the 16,000 tons formerly anticipated.

In recent months more Turkish sulphur has been sold to Roumania and Bulgaria. It is reported that Bulgaria proposes to supply sulphur to Greece in exchange for sulphuric acid under a recent trade agreement.

Pyrites

After comparatively slow shipments during the summer, strong demand has been apparent from most Continental quarters. Pyrites producers have in recent weeks been faced with heavy calls entailing high loading rates and amongst others it is reported that daily loading at the Rio Tinto pier in Huelva has several times exceeded 8,000 tons. The present flurry of activity is masking the further reduction of pyrites consumption in the United Kingdom, Belgium and France. Demand in West Germany, however, continues to expand. Competitive Cuban and Canadian supplies are seeking outlets in West Europe while rising tonnages of Jugoslav by-product pyrites find a ready market in Eastern and Central Europe.

Summary

Although sulphur prices have remained steady, the statistical position continues to weaken as stocks of Frasch sulphur in U.S.A. and Mexico mount, while those in Italy fail to diminish. Strong competition continues in world markets and in the U.S.A. Mexican supplies are enlarging their foothold.

Sulphur recovery from natural and industrial gases is constantly increasing and is now noticeably reducing the marketing opportunities for brought-in sulphur supplies, especially in the U.S.A.

The imminent start of operations at new domes—e.g. Texas Gulf Sulphur Company's Santa Anita dome in Mexico—and the development of new major sources of Frasch sulphur like Freeport's Lake Pelto and especially their new off-shore project at Grand Isle-Block 18 emphasises that for the present, actual and potential supplies have outrun the rate of expansion of demand.

UNITED STATES SULPHUR

Native Sulphur

PRODUCTION of Frasch sulphur during the second quarter of 1956, which totalled 1,612,508 tons, was 8% greater than in the previous quarter and 22% greater than in the corresponding period last year. This total has only been exceeded by output in the fourth quarter 1955 when 1,656,764 tons were produced. Output at Boling dome is reported to have exceeded 8,000 tons per day on several occasions and production at Spindletop, which started in 1952, is reported to have been boosted to a high level. Until recently its output had been restricted while Texas Gulf Sulphur Company were negotiating the purchase of adjacent concessions and reconciling conflicting matters with neighbouring oil, gas and urban interests. It is now reported that the dome is being exploited at its designed rate of ½ million tons per annum.

Apparent sales of Frasch sulphur amounted to 1,486,643 tons, about 16,000 tons (1%) more than in the previous quarter and about 47,000 tons (3%) less than during the corresponding period last year. This reduction, partly attributable to lower exports, is not reflected by domestic consumption which, on account of greater use of recovered and imported sulphur, was about 1-2% higher than in the second quarter of 1955.

The manufacture of sulphuric acid totalled 4.02 million tons (100% H_2SO_4) compared with 3.97 million tons for the second quarter last year, an increase of 1¼%. Similarly non-acid uses show small increases. Compared with the first quarter of the year sulphur use in general appears to have declined approximately 3-4%, reflecting mainly the slowing down of fertiliser production and the effect on other industries of reduced automobile manufacture. Throughout the second quarter the Index of Industrial Production declined approximately 3 points to 141 (1947/49=100) in June.

Exports of sulphur totalled 406,061 tons compared with 419,884 tons during the second quarter last year. Imports from Mexico totalled about 45,000 tons during the second quarter and were mainly take up by consumers on the Atlantic seaboard.

Producers' stocks of Frasch sulphur continued to rise throughout the quarter and at the end of June totalled 3,330,433 tons having increased by 125,000 tons. Since June of last year, when stocks were 2,875,387 tons, there has been a constant monthly increase, except during February 1956, and their present level is the highest for over seven years.

Recovered Sulphur

Production of recovered sulphur during the second quarter which totalled 112,900 tons

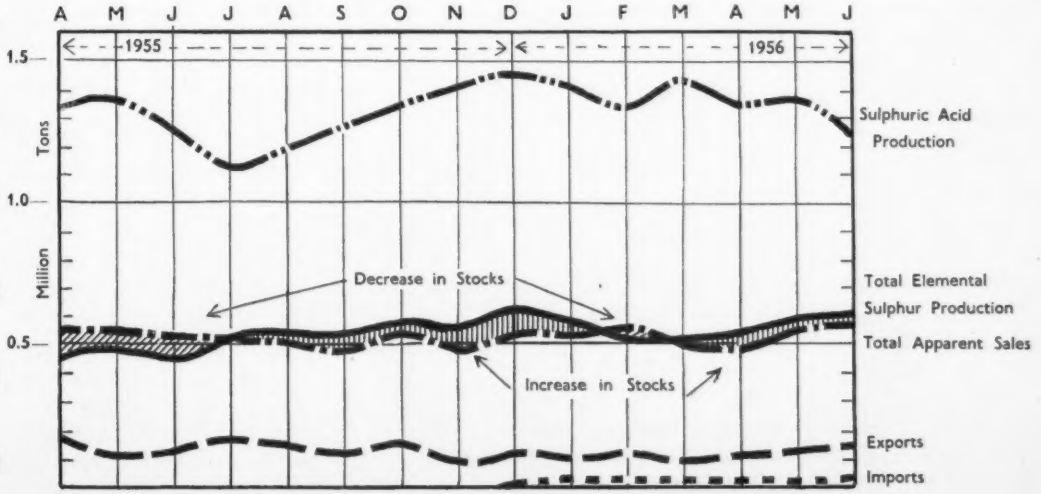


Fig. 4. U.S. Sulphur and Sulphuric Acid. April 1955-June 1956.

was 3,200 tons (3%) lower than the previous record quarter and 10% greater than the total produced in the corresponding period last year.

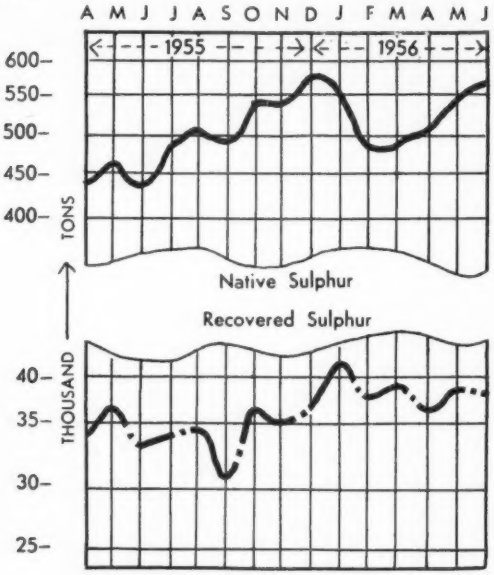


Fig. 5. Monthly Production.

Amongst new sulphur recovery projects contributing to production during the second quarter were the Aurora Gasoline Company's plant at Detroit, Michigan, and Sinclair Refining Company's plant at Marcus Hook, Pa. Both plants came on stream in February and use refinery gas as feed stock. Although the plants have a daily capacity to produce 30 and 40 tons elemental sulphur respectively, they are, in common with most recovery plants in the U.S.A., working well below capacity. Apparent sales of recovered sulphur in second quarter totalled 119,843 tons were 2,400 tons higher than in the previous record quarter. Stocks of recovered sulphur declined about 7,900 tons to 111,995 tons at the end of June.

Two important recovery projects now under construction by the Ralph M. Parsons Company, and due to be completed later this year are the Stauffer Chemical Company's plant at Le Moyne, Alabama, using carbon disulphide as a feedstock and capable of producing 140 tons per day of high purity sulphur, and that of the Associated Tide Water Oil Company in Delaware City. The latter will be the biggest sulphur recovery unit in the world based on oil refinery gases and will have a capacity of 342 tons per day. Also under construction by the Ralph M. Parsons Company, but not due on stream until next year, is a second recovery unit for the Gulf Oil Company at their Port Arthur, Texas, refinery. This unit, with a capacity of 60 tons per day, will double the refinery's sulphur output and is being constructed to deal with additional H_2S arising from the installation of a fluid catalytic cracking unit and two new "Gulfiners" which upgrade furnace and domestic oils by removing sulphur compounds. Phillips Chemical, who operate two recovery units using Texas sour natural gas as a feedstock, are to build a third unit at Andrews County, Texas, with a capacity of 60 t.p.d.

Summary 2nd Quarter 1956

(a) Production of native and recovered sulphur at 1,725,408 tons was 7% greater than the previous quarter and 23% greater than the second quarter 1955. As a result of individual producers maintaining throughout the second quarter their earlier high level of activity, Frasch sulphur output for the first half of the year was at the record annual rate of 6.2 million tons.

(b) Apparent sales of native and recovered sulphur totalled 1,606,486 tons, only 2% lower than the record sales in the corresponding period last year. During the first half year domestic consumption was at an annual rate of over 5 million tons, 5½% more than in the first half of last year; the bulk of the increase being represented by recovered sulphur and imported Mexican sulphur.

(c) Stocks of native and recovered sulphur at the end of June totalled 3,442,428 tons, the highest since 1948.

The decline of industrial activity, reflected by reduced sulphur use, which was apparent in the second quarter, became more pronounced towards the end of the period and during the subsequent months when first the steel strike and then holidays exerted their influence. Lower sulphuric acid and carbon disulphide output has since led, after peak production of

621,000 tons in July, to a cut-back in Frasch sulphur production without however affecting recovered sulphur output or imports from Mexico which increased further.

Mainly as the result of Mexican competition export sales of Frasch sulphur have declined and in the first half year are 1% lower than in the same period of 1955. This, coupled with the export price reduction earlier this year is likely to result in an overall fall in overseas revenue of about 10%. Only exceptionally high domestic sales in the last quarter would enable U.S. Frasch sulphur producers to achieve a similar gross revenue to last year's.

Freeport to exploit Off-Shore Sulphur Dome

ON the 20th September an agreement was concluded between *Humble Oil & Refining Company* and *Freeport Sulphur Company* under the terms of which Freeport will undertake Frasch sulphur mining operations at Humble's off-shore sulphur deposit known as Grand Isle-Block 18, six miles off the Louisana shore in the Gulf of Mexico. The agreement between the two companies also involves sulphur rights on two other off-shore domes known as Grand Isle-Block 16 and West Delta-Block 30. These deposits situated

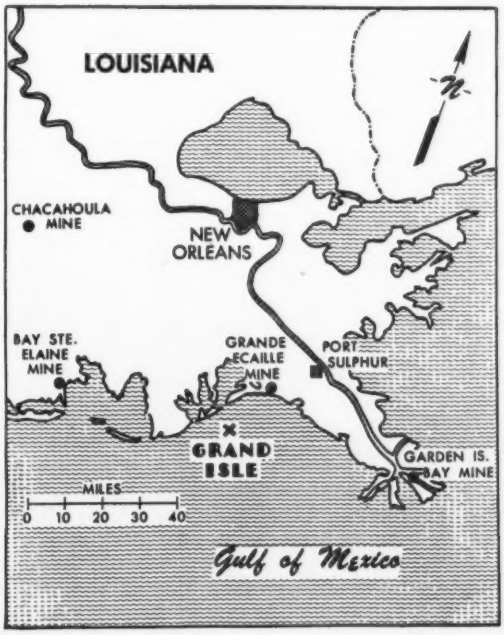


Fig. 6.

five miles west and 12 miles east of Block 18 respectively, were both discovered by Humble, and they will now be further developed by Freeport. The sulphur rights are held by Humble in leases originally executed by the State of Louisiana, and later confirmed by the Federal Government, in accordance with the provisions of the Outer Continental Shelf Lands Act. The companies have now sought approval of the Department of the Interior for the assignment of these leases to Freeport. In future, Freeport will pay basic royalties to the Federal Government and make such royalty payments to Humble that the two companies will in effect share equally the net profit after taxes, from the operations of these properties.

The deposit at Grand Isle-Block 18, was originally found, explored and developed by Humble, and these investigations have prompted a joint statement by the company's president, Mr. Hines H. Baker, and Mr. Langbourne M. Williams, president of Freeport, that it represents " a major new source of sulphur, ranking amongst the most important sulphur discoveries in recent years." In this instance sulphur was located approximately 1,700ft. beneath the floor of the Gulf of Mexico in the cap rock of a salt dome which lies beneath 45 feet of water.

The Frasch process plant which Freeport has undertaken to design, install and operate, will have to be built on a tall steel structure out of reach of storm waves. Although oil drilling rigs for under-sea operations are nowadays fairly commonplace, the requirements of the Frasch process whereby superheated water must be fed continuously into the sulphur formation to melt the sulphur which in molten form is then forced to the surface through wells, entail the accommodation of a heating plant of great capacity and weight and in consequence, this will be the largest of any of the permanent structures in the Gulf of Mexico. In the absence of storage space, it is foreseen that insulated barges will carry the sulphur in molten form to Port Sulphur, 25 miles away, where the company's principal loading and storage facilities are situated. It

is also envisaged that on the return trips the sulphur barges will haul fresh water necessary for boiler make-up and auxiliary services. The main water requirements of the Frasch process amounting to several million gallons each day, will be drawn from the Gulf.

Grand Isle will be the first sulphur mining operation to be conducted in the open water of the Gulf, raising many novel and difficult problems. Freeport's engineers already have the benefit of many years experience of operating in marshland and partially submerged locations. Of the company's active domes, three are situated in coastal marshes, which necessitated in two instances the erection of 75 to 90ft. piling to carry the plant, whilst the third plant at Bay St. Elaine, was built on a barge, floated to the site and sunk in place. Freeport also pioneered the use of sea water in the Frasch process and ocean transportation of sulphur in molten form; both developments are preconditions of successful off-shore operations.

Experience bought at a cost of $\$1\frac{1}{2}$ million, representing the company's expenditure in a prospecting venture earlier this year at San Luis Pass salt dome should now prove its value. This prospecting operation involved over two months' work at a site lying below 50 feet of water in the Gulf of Mexico 25 miles west of Galveston. The dome proved barren and Freeport in consequence relinquished their rights to four lease areas covering 5,760 acres. Unique deep water drilling techniques, which are likely to result in substantial cost reductions when Block 18 is drilled, were developed, and for the first time deep holes were drilled into a Gulf salt dome from an open barge instead of the usual and more costly permanent platform or mobile barge normally used by the oil industry. Using a drilling rig mounted on a truck amidships and cantilevered over the side of the barge, so that the drill extended 2 feet over the water, some 13 holes were drilled to a maximum depth to 1,063 feet. The barge itself, 50 x 175ft., drew only 2 feet of water and was held securely in place by a special arrangement of cable linked anchors.

Hitherto it has been doubtful whether an off-shore sulphur dome could be developed and economically exploited while the present low sulphur prices prevailed. The two companies' decision to venture into this new field at a time of ample supplies and intense competition in world sulphur markets underlines not only their enterprise but also their confidence in the ability to overcome handicaps of location and yet achieve at Grand Isle -Block 18, operating results comparable with those prevailing at established domes.

Bonnie Chemical Plant

EARLY this year International Minerals & Chemical Corporation initiated a $4 million expansion programme at their Bonnie Chemical Plant, near Bartow, Florida. It is designed to increase triple superphosphate output and will at the same time result in a correspondingly higher output of by-product uranium oxide which is being extracted from phosphoric acid, at an integrated plant by a novel and economic process.

One of the principal features of the expansion programme was the provision of greater sulphuric acid supplies. The existing plant is a brimstone burning Leonard Monsanto contact sulphuric acid plant which, built in 1953, had nominal rated capacity of 400 tons per day. As a first step early this year a series of modifications were carried out on this plant and these resulted in production of 66° Bé sulphuric acid now averaging more than 650 tons per day (100% H_2SO_4) and exceeding 700 tons per day on several occasions. It should be added that just prior to these changes, the unit was producing consistently at a rate of approximately 550 tons per day. This production increase is the result of the following modifications:

(i) Increased main blower capacity by the installation of a larger impeller.

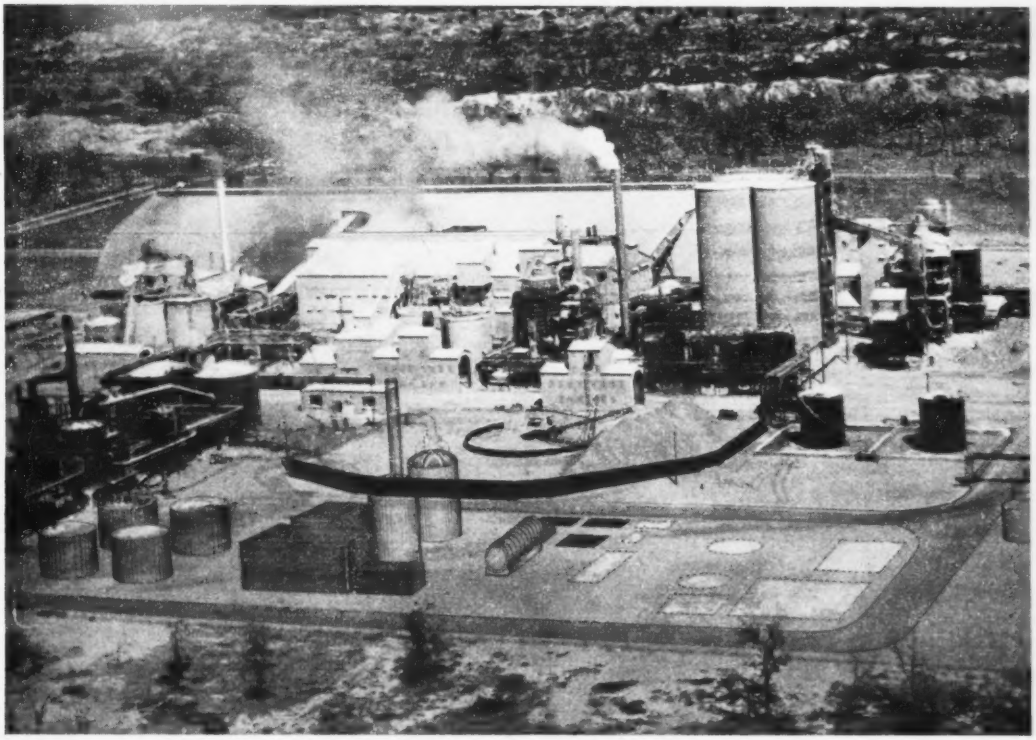
(ii) The addition to the economizer of a prefabricated section containing two rows of tubes.

(iii) The construction of an SO_3 cooler to cool the gases going to the absorber.

(iv) Alterations to the converter to permit use of additional catalyst.

(v) The installation of an air dilution duct to provide extra cooling of gases.
(vi) The installation of two additional banks of acid coolers.

To meet the eventual acid requirements a second sulphuric plant has been projected.



View of sulphuric acid installations and sketch of the duplicate new unit on projected site.

Improvements to the present plant have been incorporated in the design of the new unit which will essentially be a duplicate. Start-up of the new unit is scheduled for June 1957.

The processing steps of fertilizer manufacture have also been modified and now low grade (68%) phosphate rock is digested with sulphuric acid, resulting in weak phosphoric acid and gypsum. The gypsum is filtered out and the weak acid is sent to the uranium plant for uranium removal. The description of this process was released by the Atomic Energy Commission in April but production details remain confidential to the company. On the basis of reported throughput and uranium content of Florida phosphate rock "Chemical Engineering" last May estimated an output of 200 lb. U_3O_8 per day. After its return from the uranium plant the weak acid is concentrated to about 54% P_2O_5 by submerged combustion units, a cost and time saving innovation achieved by fitting the phosphoric acid tank with five fuel-oil fired burners from which heat is directly transferred to the acid. When concentrated, part of the acid is made to react with high grade phosphate rock (77%) resulting in triple superphosphate, while the rest after defluorisation is reacted with limestone to dicalcium phosphate. When in full operation the expanded plant will produce 475,000 tons per annum triple superphosphate and about 100,000 dicalcium phosphate, compared with 112,000 tons per annum triple superphosphate or alternatively dicalcium phosphate.

Sulphur in Italy

THE fiscal year of the Ente Zolfi Italiani which came to a close on 31st July has proved to be an encouraging period in the eventful history of the Italian sulphur industry. The crisis which in Spring 1955 appeared imminent was narrowly averted by the extensive Government aid in the form of export and production subsidies. Whereas such State support may only be justified as an emergency measure it enabled Italy to re-enter the international sulphur trade and to resume, even if only in a relatively modest way, her position as an exporter of good quality bright sulphur at internationally competitive prices.

Production and Stocks

Output of fused sulphur declined during the period under review by about 14,000 tons (7¼%) and producers' consignments to Ente Zolfi Italiani warehouses amounted to only 178,000 metric tons. In contrast, mine production of crude ore, the disposal of which for purposes other than refining is not subject to Ente Zolfi Italiani control, expanded to meet the greater requirements for direct use in sulphuric acid manufacture.

Sulphur stocks held in warehouses by Ente Zolfi Italiani on 31st July amounted to about 307,000 tons, a reduction of 34,000 tons (10%) during the year. They comprise only a small proportion of top grade material (gialla superiore) and it is estimated that about 230,000 tons is in the form of Gialla Inferiore (min. 99%S) and Buona Sicilia (min. 98%).

Domestic and Export Sales

Total sales made by Ente Zolfi Italiani during the fiscal year increased by over 90,000 tons (76%) compared with the preceding period. The expansion of domestic sales by about 9,000 tons (8½%) was attributable principally to the greater requisitions by industrial users notably rayon, rubber and chemicals; due to the severe winter which caused much damage over extensive tracts of land, agricultural demand had been much reduced.

As shown below the bulk of the increase in total sales was attributable to exports which increased nine-fold:—

	*1955**	*1956**
	metric tons	
Domestic	107,920	117,079
Exports	10,158	91,576
	118,078	208,655

*Fiscal Year ending 31st July.

Legislation

The law entitled "*Provisions for the Sulphur Industry*" was placed on the statute book on 25th June, 1956 and published in the Official Gazette No. 180 on 21st July, 1956. Its provisions, covering the increase in reconstruction funds, to 12 billion Lire and the extension of credits controlled by Ente Zolfi Italiani for modernisation of existing installations, the export subsidy of Lire 10,000 per metric ton on sulphur sold from stocks existing on 15th July 1955 and the regional production subsidy up to a total of approximately Lire 1,150 million to mines operating at above average costs, have of course been effective for over a year.

Technical Progress

The technical departments of Ente Zolfi Italiani, whose research and development work is designed to benefit the entire industry, were able to intensify their activities thanks to the availability of adequate funds from Central and Regional Government sources. Major tasks included the completion of a geological survey in Sicily and the modernisation of various extraction units. The survey extended over the Central and South central parts of the island which at present yield 82% of the total output.

Conclusion

The recent efforts of the Ente Zolfi Italiani to improve both the technical and commercial status of the Italian sulphur industry have met with a measure of success, without, however, giving rise to complacency. The problem is to reconcile the needs of rationalisation of sulphur mining and refining to achieve economic production with the social obligations towards a working population lacking in alternative occupational opportunities.

At present the industry is supported on the one hand by the Government in respect of export sales and on the other by home consumers who are forced to pay for their essential needs at more than double the world price. Although progress towards independent economic stability is necessarily slow it is vital that the industry should not lose sight of this objective. This year's operations should give some indications of the Italian sulphur industry's future prospects.

Sulphur in Mexico

THE recent months' developments of Mexico's growing Frasch sulphur industry typify the varying fortunes of this hazardous form of mineral production. The statistical picture indicates that output during the first nine months of 1956 totalled about 430,000 tons, nearly as much again as during the same period of last year. At the same time export shipments, the touchstone of financial success of these operations were 328,000 tons compared with 118,000 tons in the same period of 1955.

The bulk of this year's output originated from Pan American Sulphur Company's Jaltipan dome and this company also accounts for the greater proportion of export sales. Also contributing to this year's favourable results is the Gulf Sulphur Corporation whose new production has already successfully entered export markets. Behind these changes lies the almost complete eclipse of the Mexican Gulf Sulphur Company, the first producer of Frasch sulphur on the Isthmus of Tehuantepec, whose output and especially sales in the same period last year accounted for a significant share of the total.

PAN AMERICAN SULPHUR COMPANY

Early in September a major expansion project was completed, whereby the capacity of the plant at the company's Jaltipan dome was raised by 50%. The new facilities provide a water supply at a daily rate exceeding 5 million gallons and, according to *Mr. Harry C. Webb*, the company's president, this would permit production at an annual rate of 1 million tons as and when required. In 1956 the president expects " production in excess of and sales approximately of ½ million tons sulphur."

The new sulphur filtering plant, based on the use of diatomaceous earth to remove the dark colour and a proportion of the hydrocarbon contaminants, is now reported to be operating satisfactorily. Its rated daily capacity is in excess of 2,000 tons off-colour sulphur. It is said to result in output being much improved in colour and with a carbon content not exceeding 0.3%.

The only new project now under consideration by this company is the provision of a new loading dock at Coatzacoalcos. This new facility, by duplicating the company's existing loading dock installations, is intended to allow two vessels to load simultaneously and to result in considerable improvements in loading efficiency. It is not known whether mine to port rail facilities are similarly to be strengthened.

In a recent report to the company's stockholders the president informed them that, from gross value of sales for the year ending 31st August, of $8.28 million, the company derived a net income of $1.94 million. He estimated that net income for the calendar year 1956 would total $2.85 million ($378,000 in 1955) and net earnings after dividends $2.3 million (nil) representing $1.20 (cents 20) per share outstanding at close of period. He also anticipated that his Board of Directors would establish a regular dividend policy during the first quarter of next year.

MEXICAN GULF SULPHUR COMPANY

In a letter to stockholders in August the company's President, *Mr. P. Nachtman*, outlined the developments at San Cristobal dome leading up to the present situation which, notwithstanding his and the company's staff's unremitting efforts ever since trouble started, is serious.

This year the company is reported to have drilled 50 exploration wells of which only two showed interesting quantities of sulphur and even these were no better than wells in areas where production has not proved profitable. At the time of writing the president was of the opinion that sufficient exploratory wells had been drilled to conclude that if ten more were put down in hitherto unexplored parts of the concession and if these did not encounter rich and easily mined formations, no further efforts to ensure commercial success of the dome could reasonably be made. There has not, so far, been any indication that these crucial attempts were more successful than the preceding ones.

The company holds valuable assets in its plant, loading, storage and river barge facilities. These are reported to be the subject of negotiations while in the interim they are used by the Gulf Sulphur Corporation who are meeting some of Mexican Gulf's existing contractual obligations. Negotiations are also said to be progressing with the object of securing from some other concession holders

exploration rights over areas not so far examined but subject to the statutory necessity for this to be done.

Financial results for the first six months of the year show that net sales revenue was $291,934 (January-June 1955 $779,849) resulting in a net loss of $424,807 ($440,270) which is equal to a loss of cents 40 (cents 41) per share.

GULF SULPHUR CORPORATION

Operating successfully since early May at a daily rate of up to 400 tons sulphur the company has been building up stocks and making shipments to domestic and export markets, using storage and shipping facilities owned by Mexican Gulf Sulphur Company. Plans for the company's own storage and dock facilities, which were to have been built by its parent Hudson Engineering Company, have been postponed, pending a decision on those available and in use at present.

Representative samples of output to date show off-colour material, comparing favourably in colour with that of other Mexican producers and also with several U.S. off-colour productions.

Recent shipments are reported to show the following assay results :— Sulphur 99.3-99.6%, Organic matter 0.4-0.6%, Ash 0.01-0.03%, Moisture 0.01-0.02%. The erection of a filtering plant is contemplated.

The company's president, *Mr. Stuart C. Dorman* is reported to have been strengthening both production and sales sides of his organisation. In October/November he contemplates making a visit to the United Kingdom and Europe to acquaint himself in person with these important export markets and in a later visit to cover all major markets in North and South Africa, India and Australasia.

TEXAS GULF SULPHUR COMPANY

The company is reported to have brought its barge-mounted plant* from Houston to the site at Nopalata on the Coachapa river; steaming and start of production are said to be imminent.

TEXAS INTERNATIONAL SULPHUR CO.

At the end of July the company came to an agreement with an investment syndicate headed by Guarantee Trust Inc. of Houston, whereby in exchange for 40% of the capital stock of Central Minera S.A., Texas International Sulphur Company's Mexican subsidiary, the company would receive all the necessary funds to put it on a sound financial basis. In announcing the agreement, *Mr. A. S. Makris*, president of Texas International stated that the company had plans to build a Frasch plant with a minimum daily capacity of 1,000 tons sulphur.

Exports

Of the total exports† of 328,161 metric tons, during the first nine months of 1956, 45% were directed to U.S.A. 28½% to the United Kingdom and Europe and 26½% to Australia, India, North and South Africa.

Consumption

The ready availability of Frasch and recovered sulphur is adding buoyancy to the already booming Mexican chemical industry. New construction of six sulphuric acid plants is progressing rapidly and of these, the largest project by Guanos y Fertilizantes de Mexico, S.A., awaits approval by Nacional Financiera, S.A., the Government investment corporation controlling all developments. Its planned daily output of 200 tons per day (100% H_2SO_4) will be supplied to the dependent triple superphosphate plant which is due to start in 1958 and has a projected daily capacity of 225 tons fertilizer (43%-45% P_2O_5).

Provision for ammonium sulphate production is being made at the French financed Monclova coke ovens and steel plant. According to a study of the Bank of Mexico soil deficiency in Mexico's 15 million cultivated acres would only be remedied by the annual application of 1.17 million tons of superphosphate and 1.12 million tons of ammonium sulphate. The expansion of plant capacity to achieve even the more modest minimum emergency requirement of 325,000 tons fertilisers would, according to Nacional Financiera, be difficult to finance.

Indications to date point to gradual expansion especially in fields where Mexico can achieve virtual self-sufficiency such as—to quote only sulphur related products—tyre-cord and rayon. In the immediate future acid output may rise to about 180,000 tons annually while total domestic sulphur use is now not likely to rise as fast as had been anticipated a year ago and is not expected to exceed 75,000 tons for another year or two.

*See Quarterly Bulletin No. 13, p. 29.

†See Statistical Appendix.

UNITED KINGDOM SULPHUR

DURING the second quarter of 1956 consumption of sulphur in all its forms* amounting to 230,000 tons, was 5% less than in the preceding quarter and 7½% more than in the corresponding period in 1955. Of the total sulphur consumed it is estimated that 40% was met from indigenous sources (sulphur in anhydrite used for acid manufacture, spent oxide, zinc smelter gases, and recovered from coal and oil refinery gases), 22% from imported pyrites and 38% from imported brimstone. "Regular" sulphur use showed a moderate decline (2¾%) compared with the previous quarter, mainly as a result of reduced demand for carbon disulphide in the rayon industry, but was 11% greater than in the second quarter 1955. Compared with a year ago, the greatest expansion was recorded by anhydrite consumption, which has more than doubled. Acid sulphur use has increased by 12% but the additional anhydrite acid supplies have adversely affected the consumption of pyrites and spent oxide.

Details of consumption are as follows :—

	2nd Qtr. 1956	1st Qtr. 1956	2nd Qtr. 1955
	%	%	%
Elemental Sulphur			
Imported Brimstone ...	31	32½	31¼
Recovered, H_2S and filter cake	4¾	3	3¼
Sulphur in :			
Pyrites	25¼	25¾	30¼
Spent Oxide	15	14½	17½
Zinc Concentrates ...	6½	6¾	8½
Anhydrite	17½	17½	9¼
Total Sulphur (000 tons) ...	201	212	187

Total new production capacity increased fractionally during the quarter when 81.4% of capacity was employed. It is estimated that brimstone acid plants operated at about 82% of capacity, pyrites roasters at about 69%, spent oxide burners at 81%, and anhydrite plants at 95%.

Acid Consumption

Consumption of sulphuric acid during the 2nd quarter totalled 558,931 tons, a decrease of 6% compared with the previous quarter and an increase of 7% compared with the corresponding quarter of last year, and is primarily attributable to the 20% rise in consumption for titanium dioxide manufacture which was a record, and a 10% increase in use for fertilizer manufacture. These two groups together with rayon and transparent paper accounted for over 60% of sulphuric acid consumed in the second quarter.

British Titan Products Ltd., are planning to increase their titanium dioxide manufacturing capacity to 55,000 tons per annum. Outside the U.S.A. this company is the largest producer of titanium oxide and their plant at Grimsby has undergone continuous expansion since its

	2nd Qtr. 1956	1st Qtr. 1956	Change§ %	2nd Qtr. 1955	Change§ %
Elemental Sulphur :					
Acid : Imported	62,400	69,100	— 9¾	58,400	+ 6¾
Recovered, H_2S and Filter Cake ...	9,600	6,000	+60	5,900	+ 63
Total "Acid" Sulphur	72,000	75,100	— 4¼	64,300	+ 12
Regular	29,000	29,800	— 2¾	26,100	+ 11
Total Elemental Sulphur	101 000	104,900	— 3¾	90,400	+ 11¾
Pyrites	107,300	115,300	— 7	120,400	+ 11
Spent Oxide	63,400	63,400	— 7	69,400	— 8¾
Anhydrite	169,300	176 700	— 4¼	82,500	+105
Zinc Concentrates	43,600	47,600	— 8½	54,200	— 19½

§Percentage figures shown indicate change between earlier periods and second quarter 1956.

Imports of elemental sulphur during the 2nd quarter totalled 87,982 tons, valued at £15 5s. per ton, a decrease of just under 3% compared with the previous quarter, while the imports of pyrites showed a decrease of 31½% to 77,605 tons valued at £7 10s. per ton.

Sulphuric Acid†

Production of sulphuric acid during the second quarter totalled 562,416 tons (100% H_2SO_4) a decrease of 5¼% compared with the preceding quarter and an increase of 7¼% compared with the corresponding period last year. Output resulted from the use of the

*Excluding consumption of sulphur in anhydrite for direct manufacture of sulphate of ammonia.

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construction in 1949. The latest addition to the sulphuric acid installation is a turbulent layer pyrites roaster which, commissioned earlier this year, has raised the company's sulphuric acid capacity by 100 tons per day. Acid manufactured on the site is sufficient to process 120-150 tons per day ilmenite.

At present Laporte Titanium Ltd's plant at Stallingborough, Lincs., has an annual capacity of 18,000 tons titanium dioxide and 25,000 tons of sulphuric acid, which are supplemented by supplies mainly from the company's nearby Castleford plant. It has been recently announced that the company plans to expand production at this plant to 30,000 t.p.a. of titanium oxide.

The principal changes in individual consuming industries compared with the corresponding period in 1955 were as follows :—

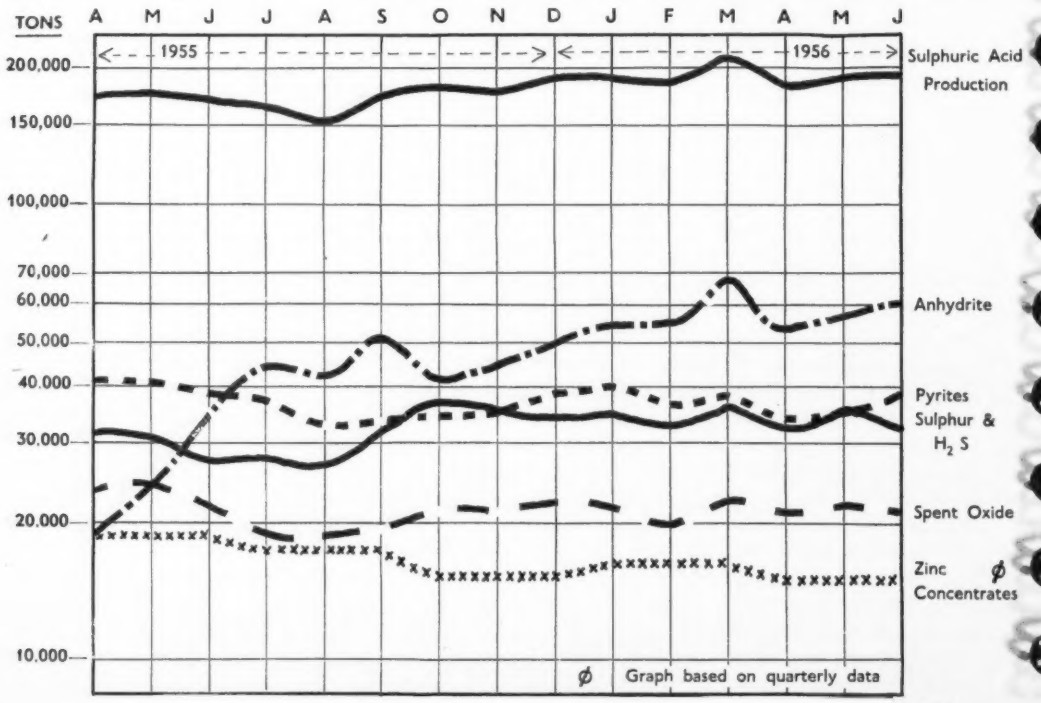
	Change	
	tons	%
Superphosphate	+ 13,600	11½
Titanium Dioxide ...	+ 11,300	20
Soap, Glycerine & Detergents	+ 8,900	79½
Sulphate of Ammonia ...	+ 5,700	8½
Explosives	— 3,400	40½

Quantitively smaller, but nevertheless important changes occurred in Bichromatic and Chromic Acid (+32%), Vegetable oils (−20%), Plastics (not otherwise classified) (+26¼%) and Sulphate of copper, nickel etc. (+32½%).

Acid usage by the main consumer groups in the respective periods was as follows :—

	2nd Qtr., 1956		*2nd Qtr., 1955*	
	000 tons	%	*000 tons*	%
Fertilizers ...	206	36.9	187	35.8
Chemicals ...	70	12.6	67	12.8
Titanium Dioxide and Lithopone ...	72	12.9	61	11.7
Rayon & Transparent Paper ...	65	11.6	66	12.6
Metallurgy ...	32	5.7	31	5.9
Oil Refining ...	16	2.8	15	2.9
Dyes	19	3.4	20	3.8
Soaps & Detergents	19	3.4	11	2.1
Miscellaneous ...	60	10.7	65	12.4
Total ...	559	100	523	100

During the second quarter stocks of acid and regular sulphur appear to have increased by 16,300 tons to 101,500 tons at the end of June. Of this increase only about 6,000 tons represent a rise of acid sulphur stocks resulting from an excess of imports and domestic production over consumption. The balance is accounted for by the inclusion, as from 1st



output.

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May, of stocks of filter cake which are estimated to total approximately 10,000 tons. Acid and regular sulphur stocks at the end of July represented 12 weeks supply.

Summary

Significant developments in the United Kingdom sulphur industry in the second quarter 1956 are as follows :—

(a) Although the Index of Industrial Production has remained virtually unchanged the consumption of sulphur and sulphurous raw materials has increased by 7% compared with the 2nd quarter of last year.

(b) The higher level of sulphuric acid consumption compared with a year ago, is mainly attributable to increased fertilizer output and the record total consumed in the manufacture of titanium dioxide and detergents.

(c) The period of re-adjustment between the use of various raw materials appears to be coming to a close as the new pattern of sulphur consumption is almost established.

The excess of anhydrite acid supplies over actual requirements, has resulted in a downward adjustment of other raw materials use, predominantly at the expense of pyrites and to a lesser extent spent oxide. As anticipated the favourable supply position and cost of brimstone is on balance resulting in increased use. The preferential position which pyrites enjoyed as the result of Government policy initiated in 1951 has now been lost. Only a major increase in sulphuric acid demand during the winter months can arrest the declining use of pyrites, as new brimstone acid plants are scheduled to come on stream from mid-1957 onwards. These provide for an output of approximately 130,000 tons per annum brimstone acid for fertilizer manufacture by Messrs. Fisons Ltd., Scottish Agricultural Industries Ltd., R. & J. Garroway Ltd. A major acid plant project by Courtaulds Ltd., in connection with staple fibre manufacture at Grimsby is also under consideration.

No further developments have as yet been announced although the possible expansion by Solway Chemicals Limited in the form of a second 100,000 tons per day anhydrite acid plant has again been rumoured. The provision of new plant facilities to make use of sulphur in industrial gases should play an increasing part in meeting the nations growing acid requirements.

Sulphur use in Nickel Refining by Sherritt Gordon Mines Limited

THE metal refining plant of the company's Chemical Metallurgical Division at Fort Saskatchewan near Edmonton, Alberta, is the only one of its kind in the world. It permits the production of refined nickel wholly by chemical means instead of the conventional smelter method and, although the plant could process several types of ores and concentrates, it was designed especially for the processing of the company's own nickel-copper concentrate. The concentrate treatment involves a number of new processes developed by Sherritt comprising ammonia leaching under pressure, followed by a series of chemical oxidation - reduction steps. The integrated plant at Fort Saskatchewan, engineered by Chemical Construction Corporation, was completed in the summer of 1954 and, costing a total of $25 million, includes an anhydrous ammonia production unit (75 tons per day) and ammonium sulphate crystallising and storage facilities. Natural gas, taken from local wells, is used extensively for steam raising and is the raw material for the manufacture of ammonia. Besides refined nickel, the main product, arising at a rate of 30 tons daily, the ore treatment process yields smaller quantities of refined cobalt and a high-grade copper residue, as well as about 200 tons per day of fertilizer grade ammonium sulphate. Most of the sulphur content of the ammonium sulphate output comes from the nickel sulphide ore itself and the balance is met by sulphuric acid purchased from the nearby plant of Inland Chemicals Canada Limited. Small quantities of elemental sulphur are also bought and used in the refinery operations.

The Refinery Process

The ore, mined at the company's Lynn Lake property in Northern Manitoba, is upgraded in a flotation mill to produce a nickel concentrate that contains 12-14% nickel and 28-30% sulphur. The following are typical ore and concentrate analyses:—

	Ni	*Cu*	*Co*	*Fe*	*S*
Ore	1.21	.58	.04	10.5	6.8
Nickel concentrate	13.88	1.52	.40	35.63	28.97
Copper concentrate	.49	30.70	.03	31.1	35. 0

The nickel concentrate is shipped by rail about 850 miles to the Refinery at Fort Saskatchewan, while the copper concentrate is sent to a copper smelter for the recovery of the copper. At the Refinery the concentrate is leached in a solution that is partly generated by the leaching process itself. The leach medium is an aqueous solution of ammonia and ammonium sulphate. In the reaction (1) the nickel goes into solution and ammonium sulphate is formed. Leach conditions of 185°F and 100 p.s.i.g. total pressure are maintained. Compressed air is used to supply the oxygen needed, and since the reactions are highly exothermic the temperature is controlled with cooling water coils and jackets.

The arrangement of the leach circuit allows the formation of unsaturated sulphur compounds, such as thionates and thiosulphates, which facilitate the removal of copper from the solution. Thus, the solution containing nickel, copper and various ammonia and sulphur compounds is first separated from the solid unleachable fraction of the concentrate and then passed on to the copper removal unit. Here the solution is heated out of contact with the air to distil off a proportion of the "free" ammonia and, simultaneously, to precipitate the copper. (2).

It is usually necessary to pass hydrogen sulphide into the solution to remove the last traces of copper. The copper sulphide produced in each case is filtered from the solution and sold to a custom smelter for treatment on a toll basis.

The solution is now virtually free of copper but contains residual quantities of ammonium thionates (tri- and tetra-) and thiosulphate, together with ammonium sulphamate, ammonium sulphate and the nickel and cobalt ammonia complexes. To ensure that pure nickel and ammonium sulphate are produced, it is necessary to remove all unsaturated sulphur compounds in the one case and ammonium sulphamate in the other, as unless removed, the thionates, thiosulphates and other unsaturated sulphur compounds caused sulphur contamination of the nickel metal recovered at a later stage. Ammonium sulphamate must also be removed, for its presence in fertiliser ammonium sulphate is undesirable.

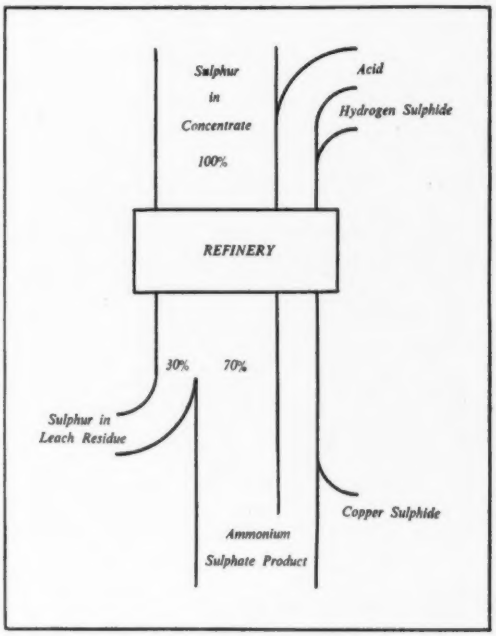


Fig. 8.

It was found that the most convenient way to remove both the unsaturated sulphur and the sulphamate is by a combined oxidation and hydrolysis treatment at high temperatures (450°F) (3).

The solution is now subjected to a hydrogen overpressure of 200 p.s.i.g. at 350°F. This causes the precipitation of pure nickel metal from the solution in the form of powder (4).

After the removal of the nickel powder the solution is prepared for the recovery of the

(1) $NiS + 2O_2 + 6\,NH_3 \rightarrow Ni(NH_3)_2SO_4$
$FeS + 2\frac{1}{4}O_2 + 2NH_3 \rightarrow \frac{1}{2}Fe_2O_3 + (NH_4)_2SO_4$

(2) $Ni(NH_3)_2SO_4 \rightarrow Ni(NH_3)_2SO_4 + 4NH_3$
$Cu^{++} + S_2O_3^{---} + 2H_2O \rightarrow 2SO_4^{--} + CuS + 4H^+$ etc.

(3) $(NH_4)_2S_2O_3 + 2NH_3 + H_2O + 2O_2 \rightarrow 2\,(NH_4)_2SO_4$
$NH_2SO_3NH_4 + H_2O \rightarrow (NH_4)_2SO_4$

(4) $Ni\,(NH_3)_2SO_4 + H_2 \rightarrow Ni^\circ + (NH_4)_2SO_4$

major portion of the sulphur content of the concentrate as ammonium sulphate. First, however, the cobalt and the residual nickel must be removed from the solution. This is done by treating the solution with hydrogen sulphide. A mixed cobalt sulphide-nickel sulphide precipitate is obtained and is filtered out leaving a pure solution of ammonium sulphate. The mixed sulphide precipitate is processed for the recovery of cobalt.

The solution is now relatively concentrated (about 550 g/l $(NH_4)_2SO_4$) and is completely evaporated for the recovery of fertiliser grade ammonium sulphate. The dried crystals are shipped in bulk or in bags according to market requirements.

General view of Fort Saskatchewan plant.

Recovery of Sulphur

About 70% of the sulphur in the concentrate is recovered. The concentrate itself is made up of a number of minerals of which the principal ones are *Pentlandite (Ni/Fe) S, Chalcopyrite ($CuFeS_2$), Pyrrhotite (FeS* with *1% Ni), Pyrite (FeS_2),* as well as small quantities of cobalt minerals and 10-15% of the original gangue. It is believed that almost all of the sulphur in the pentlandite and the chalcopyrite is recovered by the leach process. However, only 50% of the sulphur content of the pyrrhotite and very little of the pyrite sulphur is obtained. The unleached sulphides are discarded with the leach tailings residue which contains about 50% iron and 10% sulphur. Apart from ammonium sulphate arising as a by-product of the metal refining processes, small quantities are produced from sulphuric acid and anhydrous ammonia when there is no ready market for the latter product. For this purpose, an average of about 30 tons per day of acid is purchased from Inland Chemicals (Canada) Limited and delivered by pipeline.

Hydrogen sulphide required for solution purification at Fort Saskatchewan is manufactured by Sherritt from elemental sulphur and hydrogen. The unit installed has a capacity of 1½ tons per day hydrogen sulphide, but this is in considerable excess of current requirements. The sulphur in the hydrogen sulphide used to remove copper is not recovered, but a proportion of that in the mixed cobalt-nickel sulphides is recovered in the cobalt production plant.

The diagram (Fig. 8) illustrates the sulphur flow through the plant.

Sulphur thus plays a double rôle in the Refinery operations. On the one hand it provides an essential constituent of the solution in which the refining reactions are carried out, and on the other hand, it is a part of a valuable by-product of the operation.

Sulphur Recovery from Total Coal Gasification

THE decline in availability of high grade coals, suitable for carbonisation, is resulting in the increasing use of inferior grades generally with a higher sulphur content. This development is not confined to the United Kingdom. In Western Germany, where the average sulphur content of coal exceeds 1.5%, considerable research work by the coal gas industry has led to the application of novel operating methods permitting economical gas manufacture and profitable recovery of by-products, including sulphur.

The new plant of Steinkohlengas A. G. of Dorsten, Westphalia, a subsidiary of Ruhrgas A.G. of Essen, which started operating in the autumn of 1955, was designed to ensure efficient gas manufacture from lower grade coal and to permit a high degree of recovery of sulphur in a useful form. The company's gasification plant consists of six Lurgi pressure generators of 2.6 metres in diameter, and has a daily maximum capacity of 1,000 tons weakly caking gas coal (38% volatile), resulting in a crude gas output of 1.5 million cubic metres (53 million cubic feet). After extraction of the tar and benzene, the coal gas is mixed with 0.18 million cubic metres (6½ million cubic feet) of natural gas. This gas originates from the gas fields on the German-Dutch border, whence it is brought by pipe line, under high pressure, over a distance of about 50 miles. The composition of the gases is as follows:—

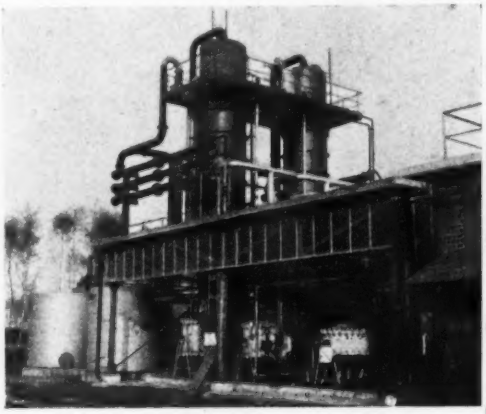
	Natural Gas	*Crude Gas*
Carbon dioxide ...	2.5%	31.5%
Hydrogen sulphide ...	0.7%	0.5%
Heavy hydrocarbons ...	1.7%	0.3%
Carbon monoxide ...	—	16.8%
Hydrogen	—	39.5%
Methane	89.0%	10.4%
Nitrogen	6.1%	1.0%

Gas cleaning

The gas mixture is then cleaned at the same pressure at which gasification was originally carried out, i.e., 20-25 atmospheres. As a safeguard against breakdowns, cleaning is carried out in two separate streams, each capable of treating some 35,000 cubic metres of gas (1¼ million cubic feet) per hour in the following manner:—

Pre-washing.—The gas stream is washed with water to eliminate the small amounts of hydrogen cyanide, the presence of which would lead to losses of the alkazid lye.

Alkazid plant.—Gas is passed countercurrently through a bubble cap scrubber, at the top of which alkazid lye at 20°C is introduced. This extracts selectively 90-95% of the hydrogen sulphide present, but only a small proportion of the carbon dioxide. The alkazid lye is regenerated by heating, resulting in a gas



Alkazid Plant.

being produced which—containing 40% H_2S and 60% CO_2—is a suitable feed for a wet catalyst sulphuric acid plant. The alkazid plant at Dorsten was supplied by Lurgi Gesellschaft für Wämetechnik m.b.H., and the alkazid lye is obtained from Badische Anilin und Soda Fabrik A.G.

Pressure Desulphurisation.—The gas from which 90-95% of the sulphur content has been removed, is then passed for final cleaning through a pressure desulphurisation plant of the type built by Gottfried Bischoff G.m.b.H., of Essen. This final purification is effected at a pressure of 20 atmospheres in the customary manner with ferric oxide. For each gas stream there are four tower purifiers, each 2.2 metres in diameter and 18 metres high, in which the hydrogen sulphide content of the gas is reduced to less than 0.2 grammes per 100 cubic metres 0.08 grains/100 cubic feet). Notwithstanding the small initial sulphur content of the gas feed, the purification mass absorbs sulphur satisfactorily up to a final content of 40-45%S. The spent

oxide is despatched to the central cleaning plant in the Ruhr, where sulphur is extracted by a carbon disulphide solvent process. The regenerated mass is returned to Dorsten.

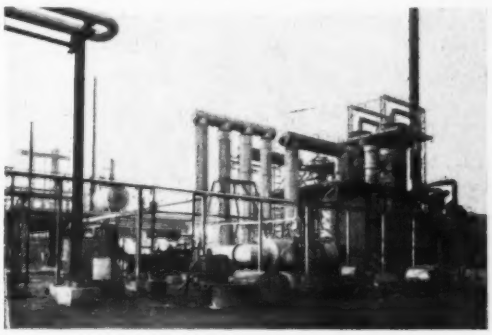
Carbon dioxide. — The sulphur-free gas stream is treated in a plant manufactured by Pintsch Bamag A.G., of Giessen, with a 20% potassium lye, which reduces its CO_2 content to 2%. The resultant gas has the calorific value and all other properties of gas normally supplied by coke oven plants in Western Germany for long distance transmission, and it can therefore be fed to the gas grid. As complete desulphurisation had been achieved prior to its removal, the CO_2 gas can now be safely exhausted to atmosphere, or in view of its high purity it may be applied to a useful purpose.

Sulphuric Acid production.

The gas arising in the regeneration of the alkazid lye and containing about 40% H_2S is converted to 60° Bé sulphuric acid in a wet catalysis contact plant built by Lurgi. This plant, too, is sub-divided into two separate units of standard design. Each unit consists of a combustion furnace, wherein hydrogen sulphide is burnt to sulphur dioxide; a waste heat boiler in which the temperature of the combustion gases is cooled to contact temperature resulting in steam of 22 atmospheres being produced; a contact converter in which SO_2 is converted to SO_3, and finally condensers. Each unit plant has a daily capacity of 30 tons 60° Bé acid. If the coal gasification plant is not operated at full capacity, e.g., weekends or in summer, there are facilities for burning elemental sulphur in order to keep up the level of sulphuric acid output.

Conclusion.

Whereas in the case of carbonisation at coke ovens or gas works about 60% of the sulphur present in the coal remains in the coke, the total gasification, as practised at Dorsten, results in the recovery of virtually the entire sulphur content of the coal in a useful and valuable form. The plant which permits complete gas purification and which results in the recovery of 90-95% of the original sulphur in the form of water clear 60° Bé sulphuric acid, is said to be operating very satisfactorily and economically. It might be added that comparison with operations at other German coal gasification plants, indicates that if desired the conversion of H_2S to elemental sulphur instead of sulphuric acid could also be effected.



Wet catalyst sulphuric acid plant.

COMPANY REPORTS

Montecatini

THE Annual Report of 1955 presented by the Board of Directors under the chairmanship of Signor Ing. Giuseppe Mazzini shows that as in the previous year turnover and output, notably of the chemical enterprises, of the Group expanded whilst in mining and metallurgy the trend was static or retrograde.

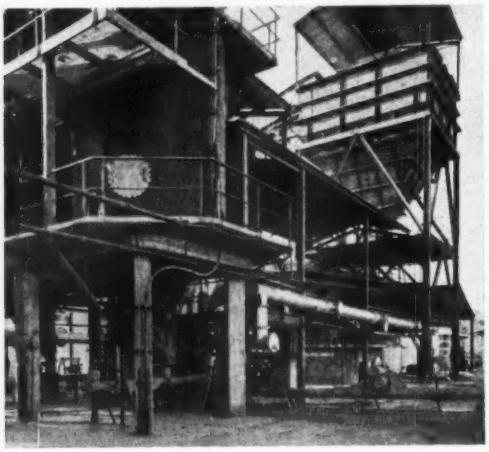
Finance

Fixed assets increased by Lire 13.2 milliard (6%) to Lire 237.9 milliard (£136 million). Most of this amount is represented by the construction of new installations such as the new nitrogen plants at Novara and Ferrara, the oil cracking plant at Ferrara as well as the titanium dioxide plant at Spinetta Marengo and expenditure on mine modernisation. Turnover increased by Lire 15.5 milliard (12.3%) to Lire 141.7 milliard, of which about 17% is accounted for by export sales, and the Group's net profit of Lire 10.8 milliard was 25% greater than in 1954.

Pyrites

During 1955 the Montecatini Group of companies produced 1,147,361 tons of pyrites,

an increase of 7.6% over the previous year and 89% of the total Italian production. As part of the programmes which had been laid down for increasing production, developing mechanisation and for the prevention of accidents, the capacity of the aerial cableway at the Niccioleta mine was increased and the drainage tunnel at Boccheggiano was completed, thus permitting the exploitation of important levels of mineralisation. Other developments were carried out at the Fenice Capanne mine where the crushing plant was improved and where during the present year it is expected that the capacity of the flotation plant will be doubled. At the Libiola mine



Montecatini-Lurgi sulphur refinery plant.

the existing flotation plant has been reconditioned while at Ortona (Island of Elba) industrial production commenced last year. To ensure an ever-increasing quantity of mineral production the company is undertaking much prospecting work, especially in the Maremma Basin as well as at Campiglia, Calceranica and Agordo in Northern Italy. Concern is expressed at the present level of the selling price of pyrites on the home market which is still that laid down by the Inter-ministerial Committee for Prices some five years ago and which is not thought to accord with the absence of restrictions either as regards quantity or in the shape of tariffs on the import of foreign pyrites.

Sulphur

Production of sulphur by the Montecatini Group further declined and in 1955 totalled 32,151 tons or about 17% of total Italian production. The Report points out that the sulphur industry has been passing through a continual crisis during the past years and that there are still no signs of recovery. Results of pilot plant tests of the Montecatini-Lurgi distillation furnace at Passarello in Sicily have given grounds for optimism although much development work remains to be done if this process is to provide an economic means of refining sulphur. It is the company's aim to promote measures which will obviate the need for permanent State assistance on a large scale.

In contrast to sulphur refining the production of crude ore has expanded and an increasing quantity is being used for the direct production of sulphuric acid.

Sulphuric Acid

With an output of 1,290,000 tons of sulphuric acid (100% H_2SO_4) in 1955 the Montecatini Group accounted for just under 68% of total Italian production. The most significant development in this sector was the start of operations in May of the contact sulphuric acid plant at P^to^ Empedocle, belonging to their associate company Soc. Akragas. In addition, the Annual Report states that the production capacity of 13 chamber acid plants has been raised by modernisation and extension of facilities, thus increasing their capacity by 10% compared with 1939.

Fertilizers

The company's production of superphosphates at 1,380,000 tons was slightly lower than in 1954. The Board believe that this is only a temporary feature and point out that the company is carrying out a vigorous extension and modernisation policy. In particular an increasing number of granulation units are being installed to replace the powdered form of fertilizer. Moreover the company is, this year, marketing a neutralized type of superphosphate, which in addition to improving the fertilizers properties, can be stored in sacks for some time.

Texas Gulf Sulphur Company

President's Report.

The Annual Report for the year ended 31st December, 1955, presented by the President, Mr. Fred M. Nelson, shows that for the second year running gross revenue from sales and net income, both before and after provision for estimated Federal income taxes, were the highest in the company's history.

Sulphur production which as in 1954 originated from the New Gulf (Boling), Moss Bluff and Spindletop Frasch plants supplemented by the recovery plant at Worland, Wyoming, was about 7% greater compared with 1954, while the company's shipments rose about 9%, an increase similar to that of total shipments of all U.S. sulphur producers. Turning to capital expenditure, the president reported that $3½ million were spent, through a subsidiary company in Mexico, on preparatory work on a sulphur dome deposit and on the construction of a Frasch process plant which is due to start production late this year. At home, the construction of a Frasch process plant near Fannett, Jefferson County, Texas, is being undertaken this year.

The company's endeavours to assure future reserves were implemented by the continuation of the world-wide exploration and research programme which in 1955 was conducted on a major scale. This work was supplemented by the substantial research and development studies to improve discovery *(sic)* and extraction methods and to expand sulphur utilization. The results of the programme to date and its future potential Mr. Nelson said, were both satisfactory.

Finance.

The company's earned income per share has risen substantially during the past two years rising to $3.23 in 1955 compared with $3.05 in 1954 and $2.45 in 1953. In 1955 the company's turnover was $94.8 million ($86.5 million in 1954) an increase of 8½% while costs and expenses rose only 6% to $62.5 million. The latter figure includes exploration expenses. In 1955 the company acquired substantial off-shore leases the cost of which is being amortised over their primary periods. Depreciation and amortisation charges during the year under review totalled about $3.4 million. Dividend payments to stockholders amounted to $2.00 per share, compared with $1.83 in 1954.

During the first 6 months of the current financial year the company's gross revenue of $44.65 million was $3.92 million (8½%) lower than in the same period of 1955. Economies in costs and expenses, aided by a smaller tax liability, limited the reduction of the company's net income; amounting to $14.75 million it was $2.19 million (13½%) smaller than in the first half of 1955.

Review of Sulphur Operations.

During 1955 the company produced just under 3 million tons of Frasch sulphur (51½% of total U.S. Frasch output) to which total must be added the output from the sulphur recovery plant at Worland, Wyoming, which has an annual capacity of about 100,000 tons. Although production at Boling dome of 2¼

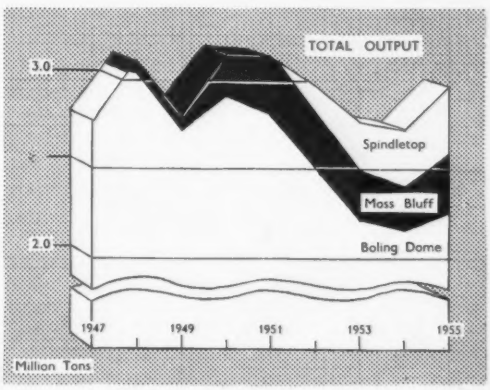


Fig. 9. Frasch sulphur output.

million tons was higher than it has been for the last two years, it is still much lower than the average of 2.85 million tons attained during the period 1947-51. Both Moss Bluff and Spindletop domes produced record tonnages of 347,000 and 355,000 tons respectively, representing increases of 33% and 15% over 1954 output.

During the first half of this year output at the company's domes is believed to have been expanded further and the company is said to have contributed a commensurate share to the increase in U.S. Frasch sulphur output which in the first half year was 8% greater than the 1955 rate of production and 19%

greater than in the first half of 1955. It is of interest that while the company's sulphur output appears to have risen substantially, operating costs and expenses were reduced, although this may possibly have been achieved by drastic cuts in capital expenditure. With regard to the drop in gross revenue, the reduction earlier this year of export prices could account for only a small part of this. Unless the company was obliged to grant substantial discounts to some domestic consumers it appears that it has suffered a sizeable reduction of its share of the domestic market which remained virtually unchanged.

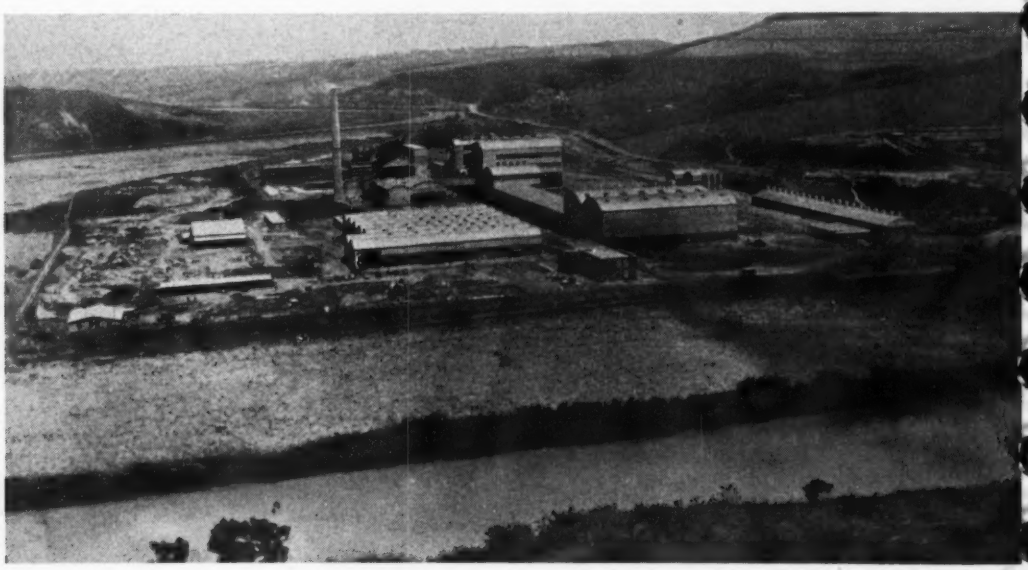
Courtaulds Limited

Amongst the salient features included in the Chairman's Annual Report for the year ending 31st March, 1956, is the large post-war capital expenditure which has been financed out of earnings. During the year under review the net increase in the Group's fixed assets was £8.8 million, while the Group's balance from trading and investment income of £18.2 million showed a decrease from the previous year's results of just over £20 million.

Amongst recent projects the following are of special interest :—

South African Industrial Cellulose Corporation (SAICCOR). In reviewing the development of this new rayon pulp company in South Africa, Sir John Hanbury-Williams said : " At the termination of the work devolving on Snia Viscosa in regard to the construction and starting up of the factory in South Africa, Snia Viscosa decided to dispose of their shareholding. The share capital of South African Industrial Cellulose Corporation is now held as to two-thirds by Courtaulds (South Africa) Pty. Limited (a wholly owned subsidiary of Courtaulds Limited) and one-third by The Industrial Development Corporation of South Africa."

The new company was officially opened by the Governor-General of South Africa in January of this year and is now successfully producing wood pulp. Situated at Umkomaas, 30 miles south of Durban, it is located in the centre of extensive eucalyptus forests. Annual capacity is in the region of 40,000 tons of wood pulp which will be used for the manufacture of man-made fibres. The Industrial Development Corporation of South Africa and Courtaulds (S.A.) Pty. Limited have underwritten the sale of the pulp for the next 15 years.



The rayon-pulp factory at Umkomaas.

British Cellophane Limited of Bridgwater, Somerset, the largest transparent paper producer in the United Kingdom, have announced that their new plant at Barrow-in-Furness, Cumberland, will enter production towards the end of 1958. The plant, which will substantially increase the company's production facilities, is designed to consume sulphuric acid and carbon disulphide at a daily rate of 150 tons and 45 tons respectively. As the plant will not include facilities for the manufacture of these materials they will be obtained from outside sources.

To date there are no plans for the recovery or neutralization of sulphur and acid in the liquid effluents, and the gaseous effluent is to be burnt or scrubbed.

Courtaulds (Alabama) Inc. Following the significant expansion which has just been completed, the company's factory at Le Moyne, Alabama, now has capacity to produce 150 million lbs. of rayon staple, three times more than in 1953. The plant will draw its sulphuric acid supplies by pipeline from the nearby new plant of Consolidated Chemical Industries Inc. and is also well placed in relation to caustic soda and carbon disulphide producers in the Mobile area as well as to ample timber supplies in Mississippi and Florida. As the result of the plant expansion Courtaulds (Alabama) Inc. now enjoy a substantially larger share of the U.S. viscose market.

Only passing reference was made to the new developments in the U.K. where Courtaulds expenditure on the present investment programme is expected to reach its peak with the completion of the new staple factory fibre at Grimsby. With an annual output of 100 million lbs. it will raise U.K. capacity by 60% and it is expected to come on stream this year.

Current Events

UNITED KINGDOM

Development at Fawley Oil Refinery

Plans announced by the *Esso Petroleum Company* in July outline a £13 million expansion programme which is primarily intended to ensure the supply of increasing U.K. requirements of fuel oils. When completed in 1958 the annual throughput capacity of the refinery will have been raised from 7½ million to 10½ million tons and new constructions will include a third crude oil distillation unit with a capacity of 9,600 tons per day, two further autodiesel hydrofiners to reduce the sulphur content of diesel fuel and improve its quality, a second sulphur recovery unit and ancillary facilities such as an additional jetty berth, new storage tanks and a second water separator plant.

The availability and assurance of supply of significant quantities of refinery gas has led to the conclusion in July of a ten-year agreement between Esso and the Southern Gas Board. Under this, Fawley refinery will supply annually 17 million therms of refinery gas which after reforming in a water-gas plant at Southampton will be equivalent to about 13 million therms of town gas and will supplant part of the normal coal-gas and nearly all the water gas made at the Southampton works. The scheme calls for the laying of a 17-mile gas main of 15" diameter from the refinery to Southampton at a cost of £¾ million to be completed by the summer of 1957.

Significant progress has also been made in respect of Esso's £9 million project announced earlier this year which provides for the supply of raw materials for synthetic rubber and chemicals manufacture. Based on the use of oil refinery feed stock, *Monsanto Chemicals Ltd.* have now announced a long-term expansion programme for the manufacture of chemicals from petroleum. On a 100-acre site adjacent to the refinery, the first plant costing £8½ million and due to be completed in 1958, will produce 10,000 tons per annum polyethylene; subsequently plants for the manufacture of copolymers of acrylonitrile, butadiene and other monomers and eventually of acrylonitrile itself are foreseen. These chemicals have a wide range of use particularly in plastics, rubber paint, paper and textile manufacture. A similar plant project essentially for synthetic rubber production involving an expenditure of £5 million is being promoted by the Dunlop Michelin, Goodyear and Firestone Rubber Companies under the name of the *International Synthetic Rubber Co.*, and

will also be based on feed stock from the Fawley refinery.

Hitherto the output of recovered sulphur at Fawley has been limited to about 14,000 tons annually resulting from the conversion of hydrogen sulphide extracted from the sour gas stream of the catalytic absorbers and the polymerisation unit. Greater refinery throughput, the cleaning of refinery gas supplied to the Southern Gas Board and above all the scale of sulphur removal from diesel oil will result in hydrogen sulphide arising in sufficient quantity to warrant the erection of the second recovery plant. The hydrogen supplies required for hydrofining are already available following the start of operations in June of the £4 million hydroformer but the two new hydrofiners and the sulphur recovery plant are not expected to come on stream until 1958. As in the existing installation H_2S extraction will be effected by the amine process and sulphur recovery in a Klaus kiln. The present expansion programme is raising the production capacity of the sulphur recovery installation at Fawley oil refinery to 28,000 tons of high-grade sulphur annually. Owing to its purity (99.9%) sulphur so produced is especially suitable for non-acid purposes, e.g., rayon, rubber, sulphites manufacture and the expansion of indigenous supplies of this material will be welcomed by these industries.

Expansion of Fisons Immingham Plant.

Work has started recently on a major expansion project at the sulphuric acid/fertilizer plant of *Fisons Ltd.*, of Immingham, which is already one of the largest in the U.K. The expansion work which is affecting virtually all sections of the factory is occasioned by the need to increase the production of triple superphosphate, which is required in greater quantities in order to meet the rising demand for the company's range of high concentration compound fertilizers (" 30 " range).

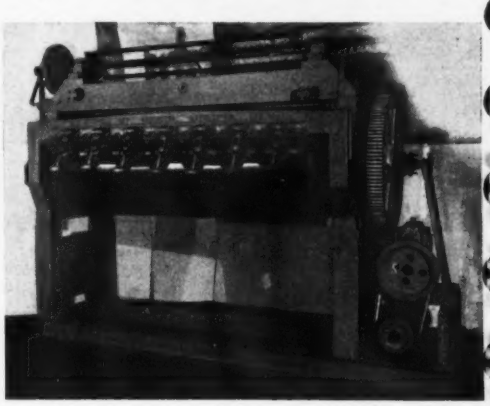
The phosphoric acid plant, which has been working at peak capacity, is being enlarged by the addition of new equipment. Modifications to the boiler plant are to improve steam-raising efficiency, and provision is being made for additional ancillary facilities such as phosphate rock, sulphur and sulphuric acid storage, workshop space and a new office block.

The principal feature of the expansion project is the provision of a new sulphuric acid plant which will make the Immingham factory completely self-sufficient in this respect. Hitherto the sulphuric acid output was augmented by bought-in supplies, including anhydrite acid from United Sulphuric Acid Corporation, Ltd., Widnes. Like the existing plant, which is the largest sulphur-burning unit in the United Kingdom, the new plant will be based on the use of elemental sulphur, and in most respects will be similar to the existing one; it will, however, have additional heat exchange equipment for generating by-product steam.

For ease of control and economic provision of services, it will be built alongside the present plant. It is designed to produce 56,250 tons sulphuric acid (100% H_2SO_4) annually, and will thus augment existing capacity by nearly two-thirds. The plant is being built by Simon-Carves Ltd., and is due to be completed next year. When in full production, the elemental sulphur requirements of the Immingham factory will total over 50,000 tons annually.

Sulphur Flaker at Grangemouth Oil Refinery

The sulphur recovery unit installed at the Grangemouth oil refinery of British Petroleum Limited incorporates a machine whereby the output of molten sulphur is turned into flakes.



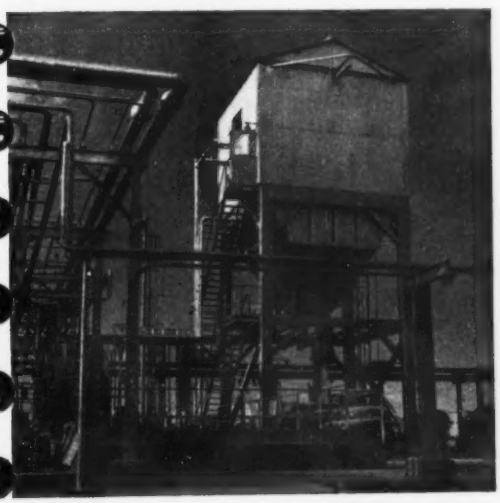
Sulphur flaking machine.

Built by *L. A. Mitchell Limited*, chemical engineers of Manchester, the flaking machine is a single drum unit fitted with internal spray pipes whereby the water is made to impinge on the inner surface of the revolving drum.

A top jacketted feed trough of special design is situated above the revolving drum to give an even distribution of molten sulphur on the drum surface. Special steps are taken to prevent the formation of a solid sulphur film on the surface of the molten sulphur in the feed trough, especially in excessively cold weather. Other special features are included, which have the effect of much improved flake quality. The spent water is usually removed from the drum by means of either a steam or water-operated ejector; the quantity of water required is in the order of 40/50 gallons per minute, per machine.

The quantity of flakes produced by each unit is approximately 2-2½ tons per hour, the flakes being approximately ¾" x ¼" x 0.025" thick. The sulphur is supplied to the flaking machine in steam jacketted lines at a temperature of approximately 280°F.

Usually the flaking machines are placed directly over bunkers of adequate capacity from which the discharge is controlled by a



Sulphur flaking and loading installations at Grangemouth.

valve so that the flaked sulphur may be loaded in bulk direct into rail waggon and/or lorries or if necessary passed first through an automatic bagging plant.

At the Grangemouth oil refinery, the sulphur flaker is located in a rolled steel housing astride a railway track and road way. The present level of sulphur recovery operations at the refinery is about 14 tons per day of high purity (99.9%) sulphur flakes representing about 70% of capacity, and the entire output is removed by road to the Broxburn Works of British Petroleum's associated Scottish Oils Ltd.

Compared with vat solidified sulphur the use of a flaking machine is said to allow significant savings in labour, and the avoidance of dust losses and contamination.

Simon-Carves Ltd. New Sulphuric Acid Plants

According to details recently made available by *Simon-Carves Ltd.*, of Cheadle Heath, Stockport it appears that the company has secured, outside the U.S.A., a large proportion of the important contracts for the construction of new sulphuric acid plants. Since the company's plant construction was reviewed* further projects have been contracted for both in the United Kingdom and overseas, resulting in the construction of 11 sulphuric acid plants with a total annual capacity of nearly 350,000 tons (100% H_2SO_4).

The rapid expansion of the fertilizer industry in New Zealand has already led to the construction of two new acid plants* and now further capacity is being added by the Bay of Plenty Fertilizer Works at Tauranga and the Southlands Co-operative Phosphate Ltd. Each plant will have a daily capacity of about 110 tons per day and the acid will be used for superphosphate manufacture. The latter superphosphate plant is being built by W. J. Fraser and Co., of Romford, Essex, at a cost of £100,000.

Construction of the acid plant for Territory Enterprises at Rum Jungle, in the Northern Territory of Australia will more than treble the existing acid making facilities needed for the leaching of uranium ore. Work on the project started in August.

Two projects have been announced for South Africa and will represent an addition of about 112,000 tons acid making capacity. New production totaling 65,500 tons (100% H_2SO_4) by the African Explosives & Chemical Industry Ltd., will be used for titanium dioxide production in conjunction with British Titan Products, while the new output of the Blyvooruitzicht Gold Mining Company's plant will be used for leaching uranium from gold slimes.

*See Quarterly Bulletin No. 9, p. 27.

In the United Kingdom Fisons Limited are expanding acid making capacity at their Immingham plant so that together with Scottish Agricultural Industries, Leith and R. & J. Garroway Ltd., Glasgow, there are now three new brimstone acid plants being built for the fertilizer industry.

The following new plants with the exception of Blyvooruitzicht Gold Mining Co. Ltd. which is to use by-product pyrites concentrate will be based on the use of elemental sulphur :—

Company	*Annual Capacity* (100% H_2SO_4) Tons
African Explosives & Chemical Industries Ltd., South Africa ...	65,000
Blyvooruitzicht Gold Mining Co. Ltd., South Africa	47,000
D.H.A. (Chemicals) Ltd., Australia	7,000
Territory Enterprises Pty. Ltd., Australia	11,000
Bay of Plenty Fertilizer Works Ltd. Tauranga, N.Z.	36,000
Southlands Co-operative Phosphate Ltd., Invercargill, N.Z.	36,000
Fisons Ltd., Immingham, England	50,000
R. & J. Garroway Ltd., Scotland	18,000
Scottish Agricultural Industries Ltd., Leith, Scotland	58,000
Shaw Wallace & Company Ltd., India	7,000
Societe Misr pour la Rayonne, Egypt	11,000

INDIA

New Projects

The Indian Ministry of Commerce and Industry has recently issued details of licences granted to the following companies for the manufacture of fertilizers :—

(a) Shaw, Wallace & Co., Madras. Construction work on the first stage, the erection of a 25 tons per day brimstone using sulphuric acid plant, has been commenced by Simon-Carves Ltd. The plant capacity is to be doubled at a later date. Initial output of superphosphate will be 33,000 tons annually.

(b) Hindustan Heavy Chemicals Ltd., W. Bengal. To produce an additional 450 tons superphosphate per month.

(c) Hyderabad Chemicals and Fertilizers Ltd. The licence covers the erection of a sulphuric acid plant with a capacity of 8,000 tons per annum, the production of superphosphate (16% P_2O_5) at a rate of 1,800-2,250 tons per month and complete fertilizers at a rate of 5,400-6,750 tons per month.

(d) Pioneer Chemical Industries (India) Limited. To erect a sulphuric acid plant at Nagpur (Madhya Pradesh) with an annual capacity of 18,000 tons (100% H_2SO_4) based on brimstone. Phosphatic and mixed fertilizers are to be produced, including superphosphate at an annual rate of 36,000 tons.

New Sulphur Find

In the course of exploration in the Rup Ganga Valley, 30 miles east of Nandprayag, a survey party led by Prof. D. N. Majumdar, and Mr. B. S. Tewari of the Geological Department of Lucknow University, discovered a deposit of native sulphur. Its extent has not yet been established, but it is considered that the ore containing approximately 60% sulphur, would lend itself readily to treatment by a refining process.

PAKISTAN

New Superphosphate Plant

Lacking an adequate outlet for their sulphuric acid output, Central Chemicals Limited have recently installed superphosphate manufacturing facilities at their sulphuric acid plant at Lyallpur, Punjab. Built in 1954, the twenty tons per day contact acid plant, which uses brimstone as raw material, has found itself unable to dispose of the major part of its output due to the adequacy of acid supplies from the Karachi plant of Pakistan Chemicals Limited. In consequence, the Government-sponsored Pakistan Industrial Development Corporation decided to contribute Rupees 1.9 million towards the total cost of Rupees 2.5 million of installing a superphosphate plant alongside the existing installation at Lyallpur. Output of superphosphate (18% P_2O_5) will be at an annual rate of 6,000 tons and the Government claims that, although superphosphate imports have in the past been insignificant as lack of education in their use has restricted demand, the entire output would be absorbed domestically.

U.S.A.

New Agricultural Sulphur Production

Wyoming Gulf Sulphur Corporation has announced plans for the construction of a new sulphur rock treatment plant designed to produce 1,000 tons per day agricultural sulphur. It will be erected on the corporation's 1,200 acre sulphur property near Thermopolis, Springs County, Wyoming, and is reported to incorporate many novel features, ensuring economic production. It is due to start commercial operation late this year.

The Arizona Sulphur Company under the presidency of Harry A. Medley, was formed earlier this year and has now started operating a grinding plant at Glendale, Arizona. This has a capacity of 25 tons per hour of finely ground dusting sulphur and 40 tons lower grade sulphur suitable for soil conditioning. The company's marketing is done through fertilizer and insecticide manufacturers in Arizona.

New Sulphur Recovery Facilities

In July *Hancock Chemical Company* brought on stream two sulphur units at Long Beach, California. Based on refinery gas the plant will have a capacity to produce 130 tons per day of high purity elemental sulphur. The sulphur is destined for manufacture into sulphuric acid to be used later for sulphonation purposes by the Richfield Oil Company, the Texas Corporation and the General Petroleum Corporation.

Pyrites Exploration in Alaska

The U.S. Department of the Interior has expressed renewed interest in the possibility of producing sulphur from the massive sulphide deposits near Horsehoe Bay on Latouche Island in the southern part of Alaska. These deposits had been explored in the first decade of this century with a view to producing copper, but consisting almost entirely of pyrite, they did not offer prospects of profitable operation. Ore lenses which have been exposed in the old mine workings have a width from a few inches to as much as 60ft. and extending in length from 1 foot to nearly 500ft. The extent of the ore bodies has never been fully determined as none of the workings have reached the limits of the mineralisation zone.

FRANCE

Reconstruction of Dieuze Acid Plant

The sulphuric acid plant of Etablissements Kuhlmann at Dieuze 30 miles north east of Nancy has recently been replaced by one of the most modern plants in Western Europe. The old plant, consisting of a lead chamber unit erected in 1870 and a contact unit built in 1928, had a total capacity of 70 tons acid per day; it was demolished after the new contact plant came into use.

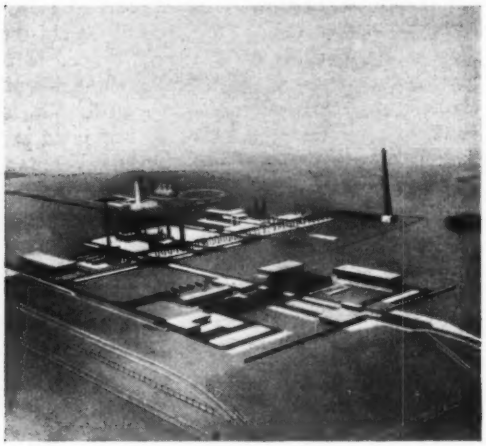
The new plant has a capacity of 150 tons per day (100% H_2SO_4) and is based on the use of foreign and domestic pyrites. It incorporates drying and grinding facilities to ensure the correct moisture content and grain size of the pyrites which are then automatically fed into the furnace. The furnace gases are cooled and after passing through an electrostatic dust precipitator, they are washed by 60° Bé sulphuric acid to remove traces of arsenic and acid mist is removed by wet electro filters. The purified gas is dried before entering the converters. Conversion to SO_3 is effected in the presence of a vanadium pentoxide catalyst and the absorption tower permits the manufacture of any type of acid as required including oleum with 20% free SO_3 and sulphuric acids of 96% to 98%, 92.3% and 78%. A noteworthy feature of the plant are the heat exchangers of advanced design which yield steam for electricity generation.

Recovered Sulphur Production.

An annual output of 60,000 tons of high purity sulphur is envisaged when the first sour natural gas cleaning and sulphur recovery plant, which is being built at Lacq for the *Société Nationale des Pétroles d'Aquitaine*, comes on stream towards the end of March, 1957. The company held up work on this project last year* as the extraction pipes were unable to withstand the highly corrosive action of the hot sour gas. In September 1955, special steel pipes were installed, and have since then given satisfactory results. The first stage of the project at Lacq, now nearing completion, provides for the daily processing of 1 million cubic metres (35½ million cubic feet) of sour natural gas containing 17.06% H_2S and 8.58% CO_2. The sour gas cleaning plant was designed and is being constructed by Foster Wheeler Française, and is based on the Girbotol process whereby the H_2S and CO_2 are absorbed in

*See Quarterly Bulletin No. 9, page 31.

ethanolamine. The gas containing high concentrations of H_2S and CO_2 is then converted to sulphur in a Klaus kiln. This recovery unit



Artist's impression of the Lacq project.

was designed and built by the Ralph M. Parsons Company of Los Angeles in association with the French firm Heurtey.

Further development of this important source of gas and sulphur is envisaged. The construction of a second plant with a capacity to treat 3 million cubic metres of gas daily, and thus raising sulphur output to about ¼ million tons sulphur annually, has been approved, and it is hoped that this unit will enter production during the second half of 1958. The company has plans extending to 1962, when they hope to be producing elemental sulphur at an annual rate of about 600,000 tons. If realised, output in 1958-9 should exceed France's total requirements of elemental sulphur, which, at present, are almost wholly imported. On the basis of the company's long-term plans, France may become an important European source of sulphur supply.

SAAR

Sulphur Extraction from Spent Oxide

Plans for a central sulphur extraction plant have been drawn up by *Saar Ferngas A.G.*, the company responsible for the long distance distribution of coke oven and town gas supplies in the Saar. If realised, spent oxide treated by a solvent extraction process will yield 4 to 5 tons pure sulphur daily at an economic cost. The resultant sulphur will be used locally in sulphuric acid and other chemicals manufacture.

BULGARIA

Sulphuric Acid Production.

It is anticipated that sulphuric acid production will reach 35,000 tons by the end of this year. Prior to the war, Bulgaria's total output was only 7,000 tons, but this had doubled by 1951 and has continued to expand since then. The entire output is based on the use of indigenous pyrites.

ISRAEL

Sulphuric Acid for Copper Leaching

To exploit the rich copper deposits near Eilat in the Negev—alleged to be part of ancient mine workings—*Israel Mining Industries* decided earlier this year to build a leaching plant to permit the economic extraction of copper from oxide ore. Designed to treat daily 1,500 tons of ore and to produce annually 8,500 tons cement copper containing about 75% Cu the plant is being built by Dorr Oliver Inc. in co-operation with the Humboldt Company who are supplying crushing and screening equipment. The anticipated sulphuric acid requirements for leaching will be provided by a new sulphuric acid plant designed by Chemiebau Dr. Zieren.

Based on the use of brimstone, the plant has been so laid out as to permit the ready installation and easy connection of additional equipment converting it to the use of pyrites, should this become necessary. The vanadium catalyst contact converter has a rated daily capacity of 80 tons (100% H_2SO_4) but the designers have guaranteed a satisfactory performance for a maximum daily output of 9 tons of acid which the ore leaching process is expected to demand. Construction work is in progress and the entire project is due for completion before the end of 1957.

Fertilizers and Chemicals Limited

According to the Progress Report for the first half of 1956, *Fertilizers and Chemicals Limited*, state that their major construction programme is complete and that emphasis is being placed on increasing production at the company's Haifa Bayside plants.

The ammonia and ammonium sulphate plants came on stream in April and both are now producing in excess of their rated capacity. Engineered and constructed by the Chemical Construction Corporation of New York the ammonia plant which has a daily capacity of 43 tons is based on liquified petroleum gas obtained by pipeline from the nearby Haifa oil refinery. In three months operation to 30th June this plant has produced 2,268 tons of ammonia of which 2,179 tons have been consumed in the manufacture of ammonium sulphate. Originally designed for a daily production of 100 tons, the ammonium sulphate plant has been averaging 170 tons per day, due mainly to technical improvements. The storage facilities for holding 25,000 tons of fertilizer are designed to ensure maximum dryness; the adjacent bagging plant has a daily capacity of up to 500 tons per day.

Sulphuric acid production has almost doubled annually since 1952 and in 1955 it amounted to 72,000 tons on a total installed capacity of the two acid plants of 105,000 tons (100% H_2SO_4). The brimstone burning acid

General view of Bayside installations showing former pyrites acid plant in foreground.

plant has a capacity of 30-35 tons per day. The pyrites flash roaster, the larger of the two, was rated at 250-280 tons per day. It is at present being modified so that elemental sulphur may be used which will raise its capacity thereby achieving a total of 330 tons per day (100% H_2SO_4). In the first half of this year acid production totalled 31,870 tons of which the bulk went into superphosphate manufacture. In 1955 pyrites were imported from Turkey in exchange for sulphuric acid and since then supplies have also been obtained from Spain; supplies of brimstone came from the U.S.A. (440 tons) and Mexico (about 4,000 tons). In the first half of this year 3,253 tons of sulphuric acid were exported to Turkey compared with 12,286 tons for the same period last year. The pyrites cinders are exported to Holland.

Fertilizers & Chemicals Limited was founded in 1946 and has rapidly become the largest industrial enterprise in Israel. One of the most up-to-date plants in the Middle East it produces a full range of nitrogenous, phosphatic and potassic fertilizers. Phosphate rock is obtained from the Negev desert, potash from the Dead Sea and refinery gas for ammonia production from the local Haifa oil refinery.

IRAQ

Kirkuk sour natural gas

In recent weeks prominence has been given to reports that the *Iraq Development Board* was contemplating the early construction of a natural gas cleaning and sulphur recovery plant at Kirkuk which would result in the production of 275 tons per day sulphur. These plans accord with one aspect of the recommendation of the World Bank to the Iraq Government in 1951, whereby the utilisation of the natural gas resources of Northern Iraq, were intended to provide the basis of a chemical industry with particular reference to nitrogenous fertilizers. In their manufacture, the sulphur radicle was to have been provided by indigenous anhydrite releasing, for other uses or export, sulphur recovered in the gas cleaning process.

There is no reason to doubt that the Iraq Development Board engineers have recently drawn up specifications and estimated the cost of a gas and sulphur recovering project at I.D. 1¼ million, but it would be surprising if the project were fully realised without the dependent industries being developed simultaneously.

JAPAN

Sulphuric Acid

Production of sulphuric acid in Japan during the first half of 1956 totalled 1,792,531 metric tons (100% H_2SO_4), an increase of just over 10% compared with the corresponding period last year. Contact acid, which represented 57% of total output, rose by 11½%,

while chamber acid output expanded by 9%. The consumption of iron pyrites, pyrrhotite, and sulphur ore which account for about 90% of the total sulphur used in sulphuric acid manufacture was 8% greater than during the corresponding period last year. The manufacture of by-product sulphuric acid from smelter gases continues to expand rapidly; the use of sulphur in copper concentrates during the first half of 1956 increased 24% compared with the corresponding period last year, while that in zinc blende rose by 12%. The use of imported pyrites has ceased altogether, while elemental sulphur and spent oxide use in acid manufacture has decreased further.

Sulphuric acid consumption during the period under review totalled 1,829,910 tons, an increase of 197,000 tons (12%). The tonnage of acid used by the fertilizer industry continues to expand (11%), and accounts for 71¼% of the total. In 1954 this industry's share was 73½%, and the lower proportion of acid now consumed points to the greater development and diversity of industrial acid usage in Japan.

The distribution of sulphuric acid use by the main consumers was as follows:—

	000 metric tons (100% H_2SO_4)	
	Jan.-June 1955	*Jan.-June 1956*
Nitrogenous fertilizers ...	809.7	842.4
Phosphatic fertilizers ...	373.8	458.7
Synthetic fibres	178.7	208.7
Inorganic chemicals ...	60.9	81.3
Dyestuffs	45.1	42.7
Iron and Steel	23.6	29.6
Petroleum	22.9	26.2
Others	118.1	140.3
Total ...	1,632.8	1,829.9

In contrast with the general trend of increased acid use, the requirements for explosives and dyestuffs have declined.. Production of synthetic fibres, which next to fertilisers used the greatest quantity of sulphuric acid, increased by about 24% compared with 1954. Production of synthetic fibre yarns now almost exceeds that of cotton yarns and Japan's output of rayon staple fibre remains the largest in the world.

The increasing level of sulphuric acid production is being stimulated by the five-year industrial rationalisation programme of the ammonium sulphate industry which was drawn up in 1953. Fifteen producers of nitrogenous fertilizers are affected, and the programme includes provision for extensive modernisation and new construction of sulphuric acid installations. The present level of sulphuric acid production which, as anticipated, is now 3.6 million tons (100% H_2SO_4) annually, may be expected to rise to 3.9 million tons (approximately 9%) in the course of the next 12 months. According to reliable estimates, chemical production, in Japan is expected to increase at an annual rate of 15%, mainly on account of expansion in petrochemicals; these will account for over one-third of new plant projects involving capital expenditure of £125 million in 1957.

PHILIPPINES

Sulphuric Acid/Fertilizer Project.

Atlas Consolidated Mining & Development Corporation, who exploit the largest copper mine in the Orient, have made considerable progress with their plans to base the manufacture of sulphuric acid and fertilizers on the use of sulphur contained in the pyritic tailings resulting from copper flotation.

Plant to the value of $1.6 million is now on order from the St. Gobain Company of France and is expected to be in operation by 1st January, 1958. The sulphuric acid plant will be located near the Corporation's copper ore flotation mill at Toledo on the Island of Cebu and, based on by-product pyritic tailings assaying 43.55% S, 38.52% Fe and 0.25% Cu it will have a capacity of 120 metric tons per day (100% H_2SO_4). This mill has at present a capacity to produce 350 tons per day of pyrites concentrates, but when the new extension to capacity is completed, this figure will be raised to 600 tons per day. Until the acid plant starts operation the pyrites will be stockpiled.

The fertilizer plant will consist of a phosphoric acid unit with a capacity of 25 metric tons per day, an acidulation unit with a capacity of 15 metric tons per hour of superphosphates (both single and triple) and a mixing, granulating, pelletizing and bagging unit with a capacity of 18 metric tons per hour.

The plant has been designed to permit easy expansion of present production facilities rated at 96,400 tons mixed fertilizers annually and expected to rise to double that figure by 1960.

Japan—Sulphuric Acid Manufacture

SULPHURIC ACID PRODUCTION

(thousand metric tons 100% H_2SO_4)

Acid produced from	Jan.-June 1955			Jan.-June 1956		
	Chamber	*Contact*	*Total*	*Chamber*	*Contact*	*Total*
Zinc Blende	25.6	59.4	85.0	30.2	68.8	99.0
Copper Ore *	60.7	28.8	89.5	74.4	47.7	122.1
Pyrites †	611.2	838.8	1,450.0	655.7	915.8	1,571.5
Total	697.5	927.0	1,624.4	760.3	1,032.3	1,792.6

	Jan.-June 1955	*Jan-June 1956*	*Change%*
Iron Pyrite	824.1	882.7	+ 7
Pyrrhotite	80.0	85.9	+ 7½
Sulphur Ore	355.5	390.1	+ 9¾
Zinc Blende	99.3	111.2	+ 12
Copper Concentrate	32.4	40.1	+ 23⅜
Cupriferous Pyrite	34.1	36.3	+ 6½
Imported Pyrite	2.0	—	—100
Spent Oxide and Elemental Sulphur	2.2	1.8	— 18
Total	1,429.6	1,548.1	

*Copper ore includes copper concentrate, crude cupriferous pyrite and smelter gas.

†Pyrites includes iron pyrites, pyrrhotite, sulphur bearing rock containing elemental sulphur and iron pyrite.

Mexico

SULPHUR EXPORTS 1956 Jan-Sept.

metric tons

	Pan American	*Mexican Gulf*	*Gulf Sulphur*	*Total*
United Kingdom	29,649	—	—	29,649
South Africa	37,887	—	—	37,887
France	34,317	—	—	34,317
India...	—	9,248	—	9,248
Australia	19,666	7,214	9,400	36 280
Sweden	9,834	—	—	9,834
Tunisia	3,052	—	—	3,052
Belgium	8,891	1,287	—	10,178
West Germany	4,017	5,370	—	9,387
U.S.A.	124,531	19,997	3,801	148,329
Total	271,844	43,116	13,201	328,161

World Elemental Sulphur Production

thousand metric tons

	1954	*1955*		*1954*	*1955*
U.S.A.	5,872.9	6,145.0	Italy (fused)	200.2	181.9
Canada	19.9	26.0	Netherlands	9.3	10.0*e*
Mexico	95.4	501.2	Norway	99.1	98.8
British West Indies	4.3	4.8	Portugal	16.1	15.4
Colombia	5.1	6.0*e*	Spain	40.8	39.0*e*
Ecuador	6.0*e*	10.0*e*	Sweden	27.4	28.4
Peru	5.0*e*	5.0*e*	Turkey	9.8	11.3
Bolivia (exports)	2.6	3.0*e*	United Kingdom	40.8	45.9
Argentina	17.0	17.0*e*	Egypt	3.7	4.0*e*
Chile	39.1	66.0	Iraq	5.0*e*	5.0*e*
Belgium	0.4*e*	0.4*e*	Iran	1.0*e*	3.0*e*
France	3.7	2.9	Formosa	5.9	6.0*e*
West Germany	68.9	70.9	Japan	182.8	199.5
Greece	2.4	3.6	Total	6,784.6	7,510.0

e estimated

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